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ENGINEERS HAND-BOOK

OF TABLES, CHARTS AND DATA ON THE APPLICATION OF CENTRIFUGAL FANS AND FAN SYSTEM APPARATUS, INCLUDING ENGINES AND MOTORS, AIR WASHERS, HOT BLAST HEATERS AND SYSTEMS OF AIR DISTRIBUTION

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PREFACE

THE use of the fan in general engineering practice is rapidly increasing, making it imperative that both the engineer and the architect become familiar with the fundamental principles governing the selection and application of fans for various purposes. Some general information has been published on the subject by the different fan builders, but what has been given out has always been incomplete and frequently misleading, and did not afford sufficient data to be intelligently employed by the engineer. Heretofore no effort has been made to collect and present under one cover the latest and most reliable engineering data concerning fans and their application to various industrial requirements.

This book is intended to be used as a guide in the selection and application of fans, heaters and kindred apparatus, and an effort has been made to so standardize the rules and data given that they may be used with any standard make of equipment. The greater part of the data presented is the result of tests and research made by the engineering staff of the Buffalo Forge Company in the testing laboratories of the company, many of the investigations being made purposely to obtain data for this book. The results of these investigations have in most cases never been heretofore published except in the proceedings of some of the engineering societies, where they were presented by the engineers of this company, and others. The rules and applications as outlined are the same as are used in this company's practice. In preparing this work the theory has been generally omitted, except in such elementary form as was necessary to an understanding of the facts given.

The information herein presented is in complete and reliable form for standard applications, but there are many cases requiring special consideration from the engineer familiar with fan installations.

OUTLINE OF CONTENTS

PART I

PROPERTIES OF AIR

In this section will be found a discussion of the physical and chemical properties of air and their general relations with respect to "fan engineering." A complete set of psychrometric charts and tables are included.

Air is a mechanical mixture of various gases, ordinarily considered as consisting of oxygen and nitrogen, but also containing a portion of moisture and carbonic acid, and a very small part of other constituents. The proportion of these components will vary under different conditions, but ordinarily pure dry air is composed as follows, in per cent.:

	By Volume	By Weight
Oxygen	20.9	23.1
Nitrogen	79.1	76.9

The moisture will vary with the humidity of the air, from 0 to 4 per cent., and the carbonic acid will vary with the purity of the air from perhaps 0.03 to 0.30 per cent., or as usually expressed, from 3 to 30 parts in 10,000.

Weight of Air

The weight of the air varies with its temperature and barometric pressure and also with the amount of moisture it contains. The weight of one cubic foot of pure dry air expressed in pounds may be determined by the formula

$$W = \frac{2.6982\ p}{459.2 + t} \qquad (1)$$

where p = absolute pressure in pounds per square inch.
t = temperature of the air in degrees F.

A convenient formula for expressing the weight of dry air at any conditions of temperature and pressure as used by Frank H. Kneeland* is

$$W = \frac{1.3253\ b}{459.2 + t} \qquad (2)$$

where b = corrected barometer reading in inches of mercury
t = temperature, deg. F.
1.3253 = weight in lbs. of 459.2 cu. ft. of air at 0° F. and 1″ barometric pressure.

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* "Some Experiences with the Pitot Tube on High and Low Velocities" Am. Soc. Mech. Engrs., Dec., 1911.

A formula expressing the weight of humid air is given in the Smithsonian Meteorological Tables as

$$W = \frac{0.080723}{1 + 0.0020389\,(t-32)} \times \frac{b - 0.378\,e}{29.921} \qquad (3)$$

where t = temperature, deg. Fahr.

b = height of barometer in inches of mercury

e = pressure due to vapor in the air in inches of mercury.

According to the latest data the above values should be slightly changed, and we will then have the following formulae as convenient forms for calculating the weight per cubic foot of either dry or moist air.

For dry air
$$W = \frac{0.0028862\,b}{1 + 0.0021758\,t} \qquad (4)$$

For moist air
$$W = \frac{0.0028862\,b - 0.001088\,e}{1 + 0.0021758\,t} \qquad (5)$$

This last gives the weight of a cubic foot of the mixture of air and vapor, either for saturated or partly saturated air.

The weight of the dry air contained in one cubic foot of saturated air may be determined from the formula

$$W = \frac{0.0028862\,b - 0.002886\,e}{1 + 0.0021758\,t} \qquad (6)$$

The weight of vapor or density in pounds per cubic foot of saturated vapor at temperature t is given by the following:

$$D_s = \frac{S\,(144 \times 0.4908\,e)}{53.35\,(459.2 + t)} \qquad (7)$$

where S is the specific weight of water vapor and may be found as

$$S = 0.6221 + 0.001815\sqrt{e} + 0.0000051\sqrt{e^3} \qquad (8)$$

The relationship between the temperature and specific weight of vapor is shown by the diagram on page 14 taken from W. H. Carrier's paper on "Rational Psychrometric Formulae."*

An approximate value for the weight of water vapor contained in one pound of dry air saturated with moisture may be determined from

$$G = \frac{0.624\,e}{b - e} \qquad (9)$$

It may be noted from the curve on page 14 that the value of 0.624 for S in the above is only correct at about 70°.

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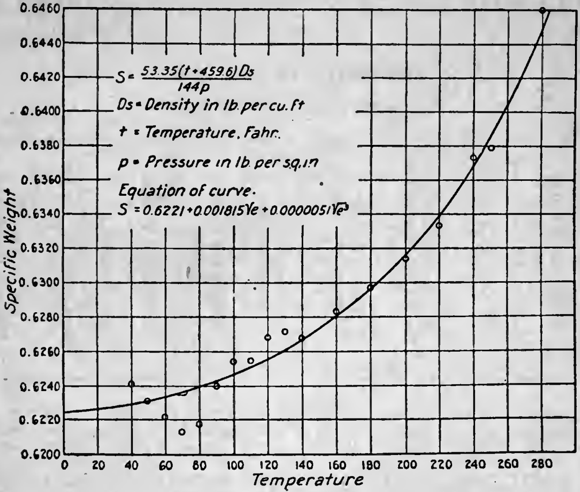
*"Rational Psychrometric Formulae" Am. Soc. Mech. Engrs., Dec., 1911.

PROPERTIES OF DRY AIR

Barometric Pressure 29.921 Inches

Temperature Degrees Fahr.	Weight per Cu. Ft. Pounds	Per Cent. of Volume at 70° F.	B. t. u. Absorbed by One Cu. Ft. Dry Air per Degree F.	Cu. Ft. Dry Air Warmed One Degree per B. t. u.	Temperature Degrees Fahr.	Weight per Cu. Ft. Pounds	Per Cent. of Volume at 70° F.	B. t. u. Absorbed by One Cu. Ft. Dry Air per Degree F.	Cu. Ft. Dry Air Warmed One Degree per B. t. u.
0	.08636	.8680	.02080	48.08	130	.06732	1.1133	.01631	61.32
5	.08544	.8772	.02060	48.55	135	.06675	1.1230	.01618	61.81
10	.08453	.8867	.02039	49.05	140	.06620	1.1320	.01605	62.31
15	.08363	.8962	.02018	49.56	145	.06565	1.1417	.01592	62.82
20	.08276	.9057	.01998	50.05	150	.06510	1.1512	.01578	63.37
25	.08190	.9152	.01977	50.58	160	.06406	1.1700	.01554	64.35
30	.08107	.9246	.01957	51.10	170	.06304	1.1890	.01530	65.36
35	.08025	.9340	.01938	51.60	180	.06205	1.2080	.01506	66.40
40	.07945	.9434	.01919	52.11	190	.06110	1.2270	.01484	67.40
45	.07866	.9530	.01900	52.64	200	.06018	1.2455	.01462	68.41
50	.07788	.9624	.01881	53.17	220	.05840	1.2833	.01419	70.48
55	.07713	.9718	.01863	53.68	240	.05673	1.3212	.01380	72.46
60	.07640	.9811	.01846	54.18	260	.05516	1.3590	.01343	74.46
65	.07567	.9905	.01829	54.68	280	.05367	1.3967	.01308	76.46
70	.07495	1.0000	.01812	55.19	300	.05225	1.4345	.01274	78.50
75	.07424	1.0095	.01795	55.72	350	.04903	1.5288	.01197	83.55
80	.07356	1.0190	.01779	56.21	400	.04618	1.6230	.01130	88.50
85	.07289	1.0283	.01763	56.72	450	.04364	1.7177	.01070	93.46
90	.07222	1.0380	.01747	57.25	500	.04138	1.8113	.01018	98.24
95	.07157	1.0472	.01732	57.74	550	.03932	1.9060	.00967	103.42
100	.07093	1.0570	.01716	58.28	600	.03746	2.0010	.00923	108.35
105	.07030	1.0660	.01702	58.76	700	.03423	2.1900	.00847	118.07
110	.06968	1.0756	.01687	59.28	800	.03151	2.3785	.00782	127.88
115	.06908	1.0850	.01673	59.78	900	.02920	2.5670	.00728	137.37
120	.06848	1.0945	.01659	60.28	1000	.02720	2.7560	.00680	147.07
125	.06790	1.1040	.01645	60.79	1200	.02392	3.1335	.00603	165.83



Specific Weight of Water Vapor

The table on page 13 gives the properties of dry air for various temperatures, and the table on page 15 the properties of saturated air. These are both based on the standard barometric pressure of 29.921 inches.

The table on page 17 giving the weights of saturated and partly saturated air for various barometric and hygrometric conditions will be found especially convenient in making calculations based on other than standard conditions. The weight in pounds per cubic foot of saturated air is given for even barometric pressures and temperatures. The decrement per degree rise in temperature and the increment per 0.1″ increase in barometer are also given, thus readily giving the weight of saturated air at any other temperature and pressure. The last column in the table gives the approximate average increment per degree wet-bulb depression which is to be added to the weight of saturated air to obtain the corresponding weight of partly saturated air.

Example. As an example of the use of the table on page 17 we will assume a case where it is desired to find the weight in pounds per cubic foot of air at a temperature of 83° dry- and 68°

PROPERTIES OF SATURATED AIR

Weights of Air, Vapor of Water, and Saturated Mixture of Air and Vapor at Different Temperatures, Under Standard Atmospheric Pressure of 29.921 Inches of Mercury

Temperature Degrees Fahr.	Vapor Pressure Inches of Mercury	Weight in a Cubic Foot of Mixture			B. t. u. Absorbed by One Cubic Foot Sat. Air per Degree F.	Cubic Feet Sat. Air Warmed One Degree per B. t. u.
		Weight of the Dry Air Pounds	Weight of the Vapor Pounds	Total Weight of the Mixture Pounds		
1	2	3	4	5	6	7
0	.0383	.08625	.000069	.08632	.02082	48.04
10	.0631	.08433	.000111	.08444	.02039	49.05
20	.1030	.08247	.000177	.08265	.01998	50.05
30	.1640	.08063	.000276	.08091	.01955	51.15
40	.2477	.07880	.000409	.07921	.01921	52.06
50	.3625	.07694	.000587	.07753	.01883	53.11
60	.5220	.07506	.000829	.07589	.01852	54.00
70	.7390	.07310	.001152	.07425	.01811	55.22
80	1.0290	.07095	.001576	.07253	.01788	55.93
90	1.4170	.06881	.002132	.07094	.01763	56.72
100	1.9260	.06637	.002848	.06922	.01737	57.57
110	2.5890	.06367	.003763	.06743	.01716	58.27
120	3.4380	.06062	.004914	.06553	.01696	58.96
130	4.5200	.05716	.006357	.06352	.01681	59.50
140	5.8800	.05319	.008140	.06133	.01669	59.92
150	7.5700	.04864	.010310	.05894	.01663	60.14
160	9.6500	.04341	.012956	.05637	.01664	60.10
170	12.2000	.03735	.016140	.05349	.01671	59.85
180	15.2900	.03035	.019940	.05029	.01682	59.45
190	19.0200	.02227	.024465	.04674	.01706	58.80
200	23.4700	.01297	.029780	.04275	.01750	57.15

wet-bulb (or a depression of 15°) when the barometric pressure is 29.40 inches. From the table on page 17 we find that the weight of saturated air at 80° and 29.00 inch barometer is 0.07034 lb. per cu. ft. Also the decrement to be subtracted is 0.00015 lb. per degree of temperature above 80°. That is, the weight at 83° and 29.00 inches would be $0.07034-(3\times0.00015) =0.06989$ lb. per cu. ft. The increment to be added per 0.1″ increase in barometer above 29.00 inches is 0.00025, so that the weight of the saturated mixture at 83° and 29.40 inches will be $0.06989+(4\times0.00025)=0.07089$ lb. per cu. ft. From the last column in the table we find the increase in weight for each degree wet-bulb depression for a temperature of 83° to be $0.000034+ 0.3\,(0.000039-0.000034)=0.0000355$.

Then the weight of moist air at 83°, 15° wet-bulb depression, and 29.40 inch barometer will be

$$0.07034-0.00045+0.001+0.00053=0.07142 \text{ lb. per cu. ft.}$$

Specific Heat of Air

The specific heat of air is the ratio of the heat required to raise the temperature of a given weight of air through one degree as compared to the heat required to raise the temperature of the same weight of water from 62 to 63 degrees Fahr., i. e., it is the B. t. u. required to raise one pound of air one degree Fahr.

The specific heat of air may be expressed as either of two factors, specific heat at constant pressure or at constant volume. It is the specific heat at constant pressure that is ordinarily referred to. The factors commonly used heretofore have been those determined by Renault—specific heat at constant pressure = 0.2375, and at constant volume = 0.1689. But recent investigation tends to show that the value 0.2375 is too low, and that it should be $C_p=0.24112+0.000009\,t$ or for ordinary purposes approximately 0.2415.*

For the specific heats of various substances see the table on page 78.

Relation of Velocity to Pressure

The laws governing the flow of air are perhaps less understood than almost any other branch of engineering data. The flow of air under high pressures must necessarily be investigated thermodynamically and the formulae are more or less compli-

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* "Rational Psychrometric Formulae" by Willis H. Carrier, Am. Soc. Mech. Engrs., December, 1911, also W. F. G. Swan, Phil. Trans. Royal Soc., Series A, Vol. 210, pp. 199-238.

WEIGHTS OF SATURATED AND PARTLY SATURATED AIR FOR VARIOUS BAROMETRIC AND HYGROMETRIC CONDITIONS—Pounds per Cubic Foot

Dry Bulb Temperature Degrees Fahr.	Barometric Pressure—Inches															Approx. Aver'g Increase in Weight per Degree Wet Bulb Depression
	26			27			28			29			30			
	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc. Dry Bulb	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc. Dry Bulb	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc. Dry Bulb	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc. Dry Bulb	Incr's Wt. per 0.1" Rise in Bar.	Wt. per Cu. Ft. Saturated Air	Decr's Wt. per Deg. Inc. Dry Bulb	Incr's Wt. per 0.1" Rise in Bar.	
0	.07500	.00016	.00029	.07788	.00016	.00029	.08077	.00017	.00029	.08365	.00018	.00029	.08654	.00019	.00029	.000015
10	.07338	.00016	.00028	.07620	.00016	.00028	.07903	.00017	.00028	.08185	.00018	.00028	.08468	.00018	.00028	.000016
20	.07180	.00016	.00028	.07456	.00016	.00028	.07733	.00017	.00028	.08009	.00018	.00028	.08286	.00018	.00028	.000017
30	.07027	.00015	.00027	.07297	.00016	.00027	.07569	.00016	.00027	.07839	.00017	.00027	.08110	.00017	.00027	.000019
40	.06879	.00015	.00026	.07143	.00015	.00027	.07409	.00016	.00027	.07675	.00016	.00027	.07942	.00017	.00027	.000021
50	.06732	.00015	.00026	.06992	.00015	.00026	.07252	.00016	.00026	.07512	.00016	.00026	.07773	.00016	.00026	.000023
60	.06588	.00015	.00026	.06843	.00015	.00026	.07098	.00015	.00026	.07353	.00016	.00026	.07609	.00016	.00026	.000026
70	.06442	.00015	.00025	.06692	.00015	.00025	.06943	.00015	.00025	.07193	.00016	.00025	.07440	.00016	.00025	.000029
80	.06297	.00015	.00025	.06542	.00015	.00025	.06789	.00015	.00025	.07034	.00015	.00025	.07280	.00016	.00025	.000034
90	.06146	.00015	.00024	.06388	.00016	.00024	.06629	.00016	.00024	.06870	.00016	.00024	.07112	.00017	.00024	.000039
100	.05991	.00016	.00024	.06228	.00016	.00024	.06465	.00016	.00024	.06703	.00017	.00024	.06939	.00018	.00024	.000044
110	.05828	.00016	.00023	.06060	.00017	.00023	.06293	.00017	.00023	.06526	.00018	.00023	.06759	.00019	.00023	.000051
120	.05653	.00018	.00023	.05882	.00018	.00023	.06111	.00018	.00023	.06339	.00019	.00023	.06569	.00020	.00023	.000059
130	.05467	.00019	.00023	.05692	.00019	.00023	.05917	.00019	.00023	.06142	.00020	.00023	.06367	.00022	.00023	.000068
140	.05262	.00021	.00022	.05483	.00021	.00022	.05704	.00021	.00022	.05925	.00022	.00022	.06147	.00024	.00022	.000078
150	.05036	.00023	.00022	.05253	.00023	.00022	.05471	.00023	.00022	.05689	.00024	.00022	.05906	.00026	.00022	.000090
160	.04788	.00025	.00022	.05001	.00025	.00022	.05216	.00026	.00021	.05430	.00026	.00021	.05644	.00029	.00021	.000103
170	.04509	.00028	.00021	.04720	.00028	.00021	.04931	.00029	.00021	.05141	.00031	.00021	.05352	.00033	.00021	.000118
180	.04197	.00031	.00021	.04404	.00031	.00021	.04611	.00032	.00021	.04818	.00034	.00021	.05026	.00036	.00021	.000134
190	.03845	.00035	.00021	.04049	.00036	.00021	.04253	.00036	.00021	.04457	.00037	.00021	.04662	.00038	.00021	.000153
200	.03449	.00040	.00020	.03650	.00040	.00020	.03851	.00040	.00020	.04052	.00041	.00020	.04254	.00041	.00020	.000173

cated. For ordinary fan work, however, where air is at low pressure but slight error is introduced if the same formulae are applied to the flow of air as are commonly used for the flow of water. The basic formula for such calculations is

$$V_s = \sqrt{2\,gh} \tag{10}$$

where V_s = velocity in ft. per second, or

$$V = 60\sqrt{2\,gh} \tag{11}$$

where V = velocity in ft. per min.

g = acceleration due to gravity in feet per second

h = head in ft. causing flow

But we also have

$$h = h'\frac{d}{12W} \tag{12}$$

where h′ = head expressed in in. of water

d = density of water

W = weight of air in lbs. per cu. ft.

Then at 70° F. and 29.92″ barometer and with dry air

$$\frac{d}{12W} = \frac{62.31}{12 \times 0.07495} = 69.75$$

and we have

$$V = 60\sqrt{2\,gh'\frac{d}{12W}} = 4005\sqrt{h'} \tag{13}$$

Thus we see that the velocity at standard conditions stated for a pressure of one inch of water will be 4005 ft. per min., and for one ounce per square inch will be

$$4005\sqrt{1.734} = 5273 \text{ ft. per min.} \tag{14}$$

The weight of dry or saturated air at other temperatures may be found from the tables on pages 13 and 15, or for any special condition of temperature, barometer, or humidity from the table on page 17, the use of which has already been explained, (see page 14).

The most convenient formulae for determining the velocity or pressure of air under different conditions of temperature, barometer and humidity, when computing test results are the following:

$$V = 1096.5\sqrt{\frac{p}{W}} \tag{15}$$

hence
$$p = \left(\frac{V}{1096.5}\right)^2 W \tag{16}$$

where V = velocity in ft. per min.
p = pressure in in. of water.
W = weight of air in lbs. per cu. ft.

The quantity of air discharged through an orifice or nozzle due to a difference in pressure may be determined from

$$Q = 1096.5\ C\ A \sqrt{\frac{p}{W}}$$

where C = coefficient of discharge.
A = area of orifice in sq. ft.
p = pressure head in in. of water causing flow of air through orifice.
W = weight of air in lbs. per cu. ft.

For values of coefficients of discharge see "Coefficients of Discharge for Air Measurements" in Part IV, Section II.

In case the pressure is expressed in ounces per square inch these formulae become:

$$V = 1444.5 \sqrt{\frac{p}{W}} \tag{17}$$

$$p = \left(\frac{V}{1444.5}\right)^2 W \tag{18}$$

and
$$Q = 1444.5\ C\ A \sqrt{\frac{p}{W}}$$

The value to be used for W to be determined for each specific case, as already explained.

Example. As an example of the application of the above we will assume a case of a fan test made under the same atmospheric conditions as those assumed for the example on page 14. That is, the air to be at 83° F. and 15° depression, with the barometer at 29.40 inches. What will be the velocity of this air at a pressure of 1.5 inches of water as measured by a pitot tube? As determined on page 16 the weight of air under the above conditions will be 0.07142 lb. per cu. ft. Then from formula (15) we find the velocity to be

$$V = 1096.5 \sqrt{\frac{1.5}{0.07142}} = 5024 \text{ ft. per min.}$$

The above formulae are sufficiently accurate for low pressures such as are ordinarily used in fan work, but for high pressures such as are met in compressed air work, the error becomes excessive and it will be found necessary to use the following thermodynamic formulae. For the flow through an orifice from a higher to a lower pressure, where the absolute initial pressure is less than twice the absolute pressure of the discharge region,

$$V_2 = 6552\sqrt{T_1\left[1 - \left(\frac{P_2}{P_1}\right)^{0.29}\right]} \qquad (19)$$

where V_2 = velocity in ft. per min. at discharge.
P_1 = absolute initial press. in lb. per sq. in.
P_2 = absolute final press. in lb. per sq. in.
T_1 = absolute temp. degrees F. of entering air.

The discharge through an orifice into a region where the pressure is greater than half the initial pressure, expressed in cubic feet of free air per minute, may then be determined by the formula

$$Q = 631600CA\frac{P_1}{\sqrt{T_1}}\sqrt{\left(\frac{P_2}{P_1}\right)^{1.42} - \left(\frac{P_2}{P_1}\right)^{1.71}} \qquad (20)$$

where Q = cu. ft. free air per min.
C = coefficient of discharge.
A = orifice area in sq. ft.

As already shown for dry air at 70° F. and 29.92 inch barometric pressure, the velocity due to a pressure of one inch of water is 4005 feet per minute and for a pressure of one ounce per square inch is 5273 feet per minute. Since the velocity varies as the square root of the pressure, we have

$$\frac{V}{V_0} = \sqrt{\frac{p}{p_o}} \text{ or } V = V_0\sqrt{\frac{p}{p_o}} \qquad (21)$$

Taking p_o as unit pressure, and V_0 the velocity corresponding thereto, assuming dry air at 70° F. and 29.92 inch barometer, the above relation reduces to

$$V = 4005\sqrt{p} \qquad (22)$$

When the pressure is taken in inches

$$\text{or } V = 5273\sqrt{p} \qquad (23)$$

when the pressure is expressed in ounces.

The table on page 21 gives the velocity of dry air at standard conditions for various pressures expressed both in inches and ounces. The two tables on pages 22 and 23 give the corresponding velocities of dry air under standard barometric pressure of

CORRESPONDING PRESSURES AND VELOCITIES OF DRY AIR AT 70° AND 29.92 INCHES BAROMETER

Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.	Inches of Water	Ounces per Sq. In.	Velocity Ft. per Min.
.05	.0289	896	4.77	2.750	8745
.10	.0577	1266	5.00	2.884	8943
.20	.1154	1791	5.20	3.000	9134
.25	.1443	2003	5.50	3.172	9392
.30	.1730	2193	6.00	3.460	9810
.40	.2308	2533	6.07	3.500	9864
.43	.2500	2637	6.50	3.749	10210
.50	.2884	2832	6.94	4.000	10545
.60	.3460	3102	7.00	4.037	10595
.70	.4037	3351	7.50	4.326	10968
.75	.4326	3468	7.80	4.500	11187
.80	.4614	3582	8.00	4.614	11328
.87	.5000	3729	8.67	5.000	11792
.90	.5190	3800	9.00	5.190	12015
1.00	.5768	4005	9.54	5.500	12367
1.25	.7209	4478	10.00	5.768	12665
1.30	.7500	4566	10.40	6.000	12915
1.50	.8650	4905	11.00	6.344	13282
1.73	1.0000	5273	11.27	6.500	13445
1.75	1.0092	5298	12.00	6.921	13875
2.00	1.1535	5664	12.14	7.000	13950
2.17	1.2500	5895	13.00	7.497	14440
2.25	1.2975	6007	13.87	8.000	14913
2.50	1.4418	6332	14.00	8.074	14985
2.60	1.5000	6457	15.00	8.650	15510
2.75	1.5860	6641	15.61	9.000	15820
3.00	1.7300	6937	16.00	9.227	16020
3.03	1.7500	6976	17.00	9.805	16513
3.25	1.8740	7220	17.34	10.000	16675
3.47	2.0000	7457	18.00	10.380	16990
3.50	2.0185	7492	19.00	10.960	17456
3.75	2.1630	7756	19.07	11.000	17488
3.90	2.2500	7910	20.00	11.535	17910
4.00	2.3070	8010	20.81	12.000	18265
4.25	2.4510	8256	22.54	13.000	19012
4.34	2.5000	8337	24.28	14.000	19730
4.50	2.5950	8496	26.01	15.000	20420
4.75	2.7395	8729	27.74	16.000	21090

CORRESPONDING VELOCITIES FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES
29.92 INCHES BAROMETER

Pressure		Temperature Degrees Fahr.									
Inches	Ounces	50°	60°	70°	80°	100°	150°	200°	300°	500°	550°
.1	.0577	1242	1255	1266	1278	1300	1358	1413	1516	1704	1830
.2	.1154	1757	1776	1791	1808	1841	1921	2000	2145	2411	2590
.25	.1443	1965	1986	2003	2022	2059	2149	2235	2399	2696	2895
.3	.1730	2151	2175	2193	2214	2254	2352	2447	2626	2952	3175
.4	.2308	2485	2512	2533	2557	2603	2717	2827	3033	3409	3660
.5	.2884	2778	2808	2832	2859	2911	3038	3160	3391	3812	4095
.6	.3460	3043	3076	3102	3131	3188	3327	3462	3715	4175	4490
.7	.4037	3287	3323	3351	3383	3445	3595	3740	4013	4510	4850
.75	.4326	3402	3439	3468	3501	3565	3720	3870	4153	4668	5020
.8	.4614	3524	3552	3582	3616	3682	3843	3997	4290	4821	5185
.9	.5190	3728	3768	3800	3836	3906	4076	4241	4550	5114	5500
1.0	.5768	3929	3971	4005	4043	4117	4296	4470	4796	5390	5795
1.25	.7209	4393	4440	4478	4520	4602	4804	4997	5362	6027	6470
1.50	.8650	4812	4864	4905	4952	5042	5262	5474	5874	6602	7100
1.75	1.0092	5197	5254	5298	5348	5446	5683	5912	6344	7131	7655
2.00	1.1535	5556	5616	5664	5718	5822	6076	6320	6783	7624	8195
2.25	1.2975	5892	5956	6007	6064	6174	6443	6704	7193	8085	8690
2.50	1.4418	6211	6278	6332	6392	6508	6792	7066	7582	8523	9150
2.75	1.5860	6514	6585	6641	6704	6827	7124	7412	7952	8938	9600
3.00	1.7300	6807	6879	6937	7003	7130	7440	7742	8307	9336	10000
4.00	2.3070	7857	7942	8010	8086	8233	8592	8940	9581	10780	11580
5.00	2.8840	8772	8867	8943	9027	9192	9593	9980	10710	12037	12900
6.00	3.4600	9623	9728	9810	9903	10083	10523	10950	11750	13203	14180

CORRESPONDING VELOCITIES FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES

29.92 INCHES BAROMETER

Pressure		Temperature Degrees Fahr.									
Ounces	Inches	50°	60°	70°	80°	100°	150°	200°	300°	500°	550°
.1	.1734	1635	1653	1667	1683	1714	1788	1860	1996	2244	2410
.2	.3468	2313	2338	2358	2380	2424	2530	2632	2824	3174	3405
.3	.5202	2833	2864	2888	2915	2969	3098	3223	3458	3887	4175
.4	.6936	3272	3307	3335	3367	3428	3578	3722	3994	4489	4850
.5	.8670	3658	3698	3729	3765	3833	4000	4162	4466	5019	5395
.6	1.0400	4007	4051	4085	4124	4199	4382	4559	4892	5498	5900
.7	1.2140	4329	4375	4412	4454	4535	4733	4924	5283	5938	6380
.8	1.3870	4626	4677	4716	4761	4848	5059	5263	5647	6347	6820
.9	1.5605	4907	4960	5002	5050	5142	5366	5582	5990	6733	7250
1.0	1.7340	5172	5229	5273	5323	5420	5656	5884	6314	7098	7625
1.1	1.9073	5426	5485	5531	5584	5685	5933	6172	6623	7444	8000
1.2	2.0808	5664	5725	5774	5828	5935	6194	6443	6914	7772	8350
1.3	2.2540	5896	5960	6011	6068	6179	6448	6708	7198	8090	8700
1.4	2.4275	6120	6186	6238	6297	6412	6692	6962	7470	8396	9020
1.5	2.6010	6335	6404	6457	6520	6638	6928	7207	7733	8692	9345
1.6	2.7742	6543	6614	6670	6734	6856	7155	7444	7987	8977	9650
1.8	3.1210	6942	7017	7076	7143	7274	7591	7897	8473	9524	10220
2.0	3.4680	7315	7395	7457	7528	7665	8000	8322	8930	10037	10780
2.2	3.8145	7672	7755	7820	7894	8038	8462	8727	9364	10525	11300
2.4	4.1615	8012	8099	8168	8245	8396	8762	9115	9781	10995	11800
2.6	4.5080	8338	8429	8500	8581	8737	9118	9486	10179	11440	12280
2.8	4.8550	8654	8748	8822	8906	9068	9464	9845	10564	11873	12750
3.0	5.2020	8960	9057	9134	9220	9388	9798	10193	10938	12293	13200

29.92 inches for different pressures and temperatures. One table gives the velocity for even parts of an inch and the other for even parts of an ounce, with the corresponding pressure in the other unit.

Effect of Temperature and Barometric Pressure on Velocity

If considered at the same pressure the effect of changing the temperature of the air will change the corresponding velocity in direct proportion as the square root of the absolute temperatures. That is

$$V = V_0\sqrt{\frac{460+t}{460+t_0}} \tag{24}$$

The tables on pages 22 and 23 give the corresponding velocities for dry air at various pressures and temperatures, but the velocity for any other temperature may be determined from the above formula.

In connection with fan work we have the same relation—that is at constant pressure, the speed, capacity and horsepower of the fan varies as the square root of the ratio of the absolute temperatures. At constant velocity the weight and pressure of the air handled will vary inversely as the ratio of the absolute temperatures.

The velocity of air at constant pressure not only varies with any change in temperature, but also with every change in barometer. The velocity of the air varies inversely as the square root of the ratio of the barometric pressures.

Then we will have

$$V = V_0\sqrt{\frac{b_0}{b}} \tag{25}$$

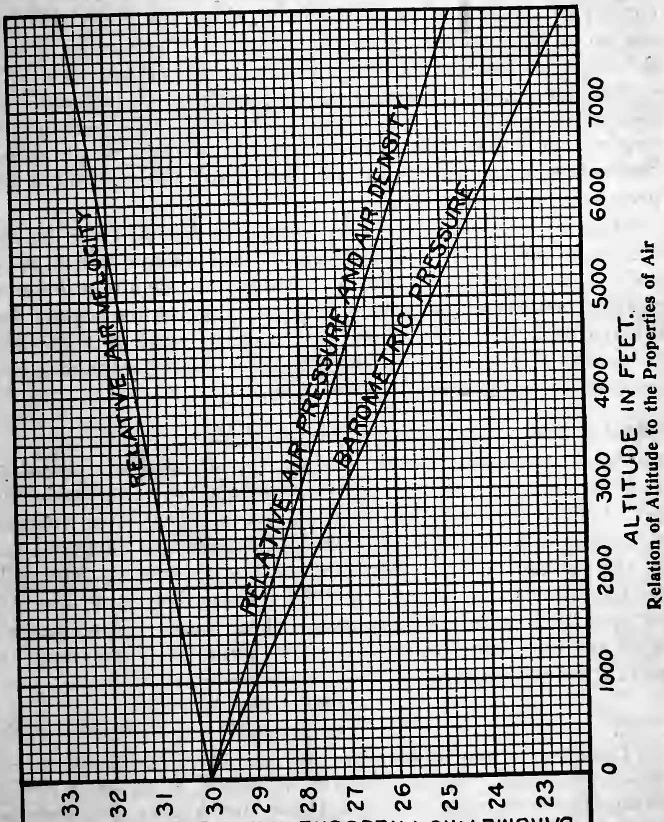
or where we wish to correct for both temperature and barometer

$$V = V_0\sqrt{\frac{460+t}{460+t_0}} \times \sqrt{\frac{b_0}{b}} \tag{26}$$

In the above formulae V represents the velocity of the air at temperature t degrees Fahr. and barometer b, while V_0 is the corresponding velocity at temperature t_0 and barometer b_0.

Relation of Altitude to the Properties of Air

The diagram on page 25 shows graphically the effect of different altitudes on the properties of air, and the two lines of relative air velocity and of air pressure and density are especially convenient in fan calculation.



Relation of Altitude to the Properties of Air

As an illustration of the use of this diagram assume a case where a fan is to handle 150,000 A. P. M. at 0.5 inch static pressure at an altitude of 5000 feet. We must determine what sea level conditions correspond to these conditions at the given altitude and so be able to select a fan of the required capacity. From the chart we find the relative pressure at this altitude is 0.825, so that the sea level pressure corresponding to 0.5 inch at 5000 feet altitude will be $0.5 \div 0.825 = 0.6$ inch. The horsepower required to operate this fan will be 82.5 per cent. of the rated horsepower as given in the fan tables for the corresponding pressure of 0.6 inch static.

Any given amount of air as commonly specified will be increased in volume by this same ratio when we consider an altitude of say 5000 feet. Thus if we ordinarily require a definite quantity of air for a certain purpose this volume should be divided by 0.825 to determine the capacity required if the apparatus is to be installed at an altitude of 5000 feet, and a fan selected to handle this greater volume.

Effect of Temperature on the Volume of Air

Air at constant pressure changes its volume almost exactly in proportion to its absolute temperature (460 + temperature deg. Fahr.) The table on page 13 gives the relative volume of a given quantity of air at various temperatures as compared to the volume at 70°. For instance, the volume at 160° will be 1.17 times the volume at 70°. Expressed as a formula for use with other temperatures than those given in the table we will have, where Q is the volume at temperature t and Q_0 the volume at t_0

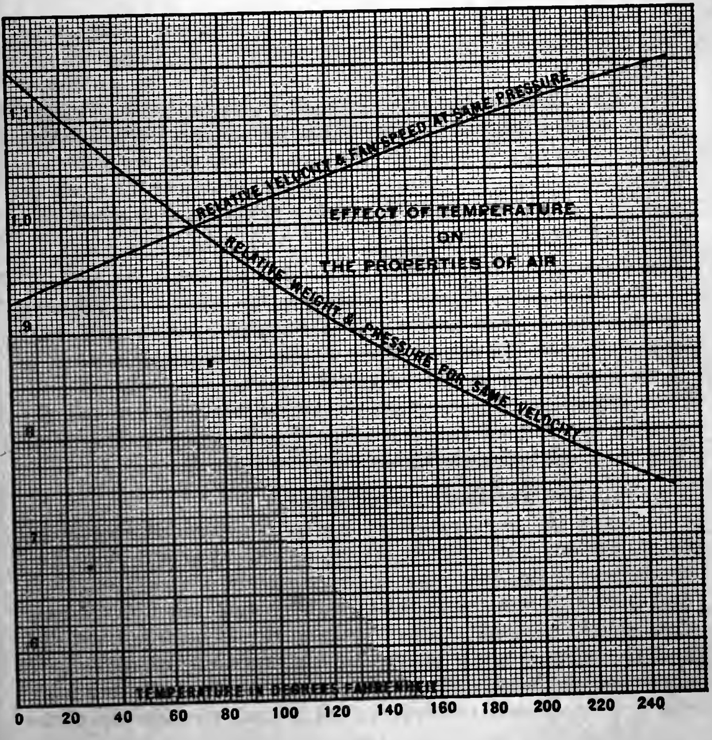
$$Q = Q_0 \left(\frac{460 + t}{460 + t_0} \right) \tag{27}$$

The effect of temperature on the various properties of air is shown graphically by the diagram on page 27. As air at 70° is commonly used as a standard, these curves give the various relationships relative to air at 70°. Inasmuch as the fan tables given herein are based on air at 70° F., the upper curve of this diagram is especially applicable to fan calculations. Thus we see that if the air to be handled by a fan is at 140°, the velocity and fan speed would have to be increased to 106.5 per cent. of that given in the tables. Or if the velocity remains the same, the pressure and weight of air handled at 140° will be only 88 per cent. of the rated capacity.

Effect of Humidity on Velocity

It may be noted that the tables herein given, consider the various properties of **dry air** at the standard temperature and barometric pressure. But as a matter of fact, atmospheric air is not dry, so that a correction is necessary in order to reduce the actual observed velocity to the standard condition of dry air. This may be accomplished by means of the following relation, the cubic feet per pound of air being determined from the psychrometric charts on pages 36 and 37.

$$\frac{\text{Actual vel.}}{\text{Vel. Dry Air}} = \sqrt{\frac{\text{Cu. ft. per lb. air as observed}}{\text{Cu. ft. per lb. dry air}}} \qquad (28)$$



HUMIDITY

Humidity is the moisture or water vapor mixed with the air in the atmosphere, and the weight of water vapor a given space will hold is dependent entirely on the temperature. The amount of vapor in any given space is independent of the presence of air, the only effect the air has being due to its temperature.

Absolute Humidity

Absolute humidity is the weight of a given volume of water vapor at a given temperature and percentage of saturation and is usually expressed as grains per cubic foot. The tables on pages 38 to 45 give the weight of water vapor per cubic foot at different temperatures and percentages of saturation.

Relative Humidity

Relative humidity is the ratio of the weight of water vapor in a given space as compared to the weight which the same space is capable of containing when fully saturated at the same temperature. It is the ratio of the absolute humidity for the given condition to the absolute humidity at saturation. The quantity of moisture mixed with the air under different conditions of temperature and saturation is usually determined by means of some form of instrument in which a dry-bulb and a wet-bulb thermometer are used.

Dew-Point

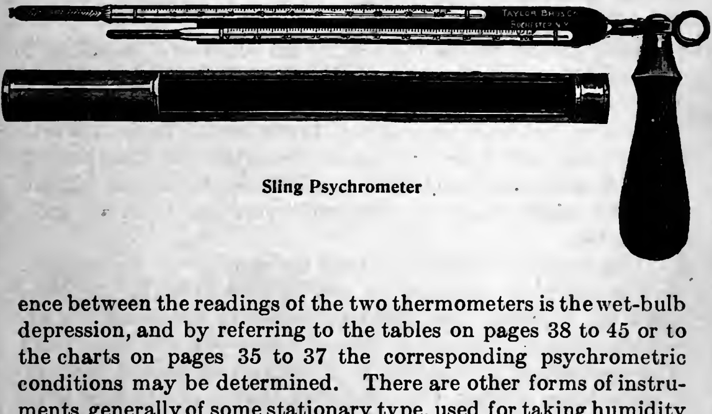
The dew-point is the temperature at which saturation is obtained for a given weight of water vapor, or the point where any reduction in temperature would cause condensation of some of the water vapor. Any given amount of moisture must have some temperature at which saturation will occur and any further lowering of the temperature will cause condensation. This then will be its dew-point.

Dry-Bulb and Wet-Bulb Thermometer

Usually the temperature of the air is determined by means of an ordinary or dry-bulb thermometer. The wet-bulb thermometer has the bulb covered with a piece of clean soft cloth and should be wet or dipped in water before taking a reading. Care should always be taken to keep the cloth free from dirt and to use pure clean water. This thermometer will give a depressed or lower reading than that of the dry-bulb thermometer in proportion to the evaporation from the wet surface of the cloth, and this depression is a measure of the amount of moisture in the air. This depressed reading corresponds to the temperature at which the air would normally saturate without any change in its heat contents. That is, the total heat in the air remains constant at a constant wet-bulb temperature. In order to obtain a true reading it is necessary that the thermometer be placed in a strong current of air.

The Sling Psychrometer

This instrument consists of a wet- and a dry-bulb thermometer mounted on a strip of metal and provided with a handle which permits of the thermometer being rapidly whirled through the air. When being used the instrument should be whirled continuously until no further drop in the wet-bulb reading is noted. The difference between the readings of the two thermometers is the wet-bulb depression, and by referring to the tables on pages 38 to 45 or to the charts on pages 35 to 37 the corresponding psychrometric conditions may be determined. There are other forms of instruments, generally of some stationary type, used for taking humidity readings, but the instrument described is reasonably accurate and is the one used by the United States Weather Bureau.

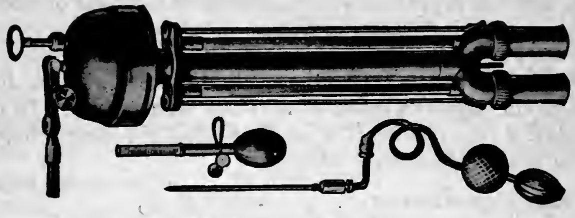


Sling Psychrometer

The Aspiration Psychrometer

The aspiration psychrometer shown herewith is more accurate than the sling psychrometer, as it will be noted from the cut that the bulbs of the two thermometers are enclosed in highly polished tubes so the temperature is not affected by radiation from surrounding objects.

A circulation of air is induced through the tubes by a small suction fan located in the top of the instrument. This fan is



Aspiration Psychrometer

driven at a constant speed by means of the clockwork, which will drive the fan several minutes with one winding, giving a uniform strong current to produce a rapid evaporation from the wet-bulb. The small rubber bulb is used to moisten the wick or muslin covering the wet-bulb.

Relation of Humidity to Heating

To understand more thoroughly the relation of humidity to heating, it is necessary to know that the temperature felt by the body, or the sensible temperature, as it is called, corresponds to the temperature of the wet-bulb thermometer; hence, the drier the air the greater is the difference between the actual and sensible temperatures. Dry air heated much above the normal will still be chilly, slight drafts are very noticeable and colds are easily contracted.

The excessive evaporation from the skin lowers the temperature of the body very rapidly, and as a result higher temperatures are required than would be necessary for comfort if the proper amount of humidity were present. On the other hand, if the percentage of humidity is excessive, evaporation from the body is below normal, with the result that the body heat is not radiated as speedily as is necessary for comfort. In general, the higher the humidity maintained the lower the temperature required for the same degree of personal comfort.

Relation of Dry-Bulb, Wet-Bulb and Dew-Point Temperatures

The relation between the temperature as shown by the dry-bulb and wet-bulb thermometer, and the relation to the dew-point should be thoroughly understood by those expecting to become at all familiar with the subject of humidity.

Dew-point, as previously stated, is the temperature at which saturation is obtained for a given amount of water vapor. In other words, the air is at the dew-point when it contains all the moisture it will hold at a given temperature, and when it is impossible to get the air to absorb more water vapor without raising the temperature. When air has been reduced to the dew-point, both wet- and dry-bulb thermometer register exactly the same; for instance, air at 50° temperature and 100 per cent. saturation will contain 4.076 grains of moisture per cubic foot, under which condition the dry-bulb and wet-bulb thermometer will both register 50°. If this air is heated, both thermometers will rise, but the wet-bulb temperature will rise more slowly and the relative humidity will be rapidly reduced: the dew-point remains constant at 50°, since any given number of grains of moisture per cubic foot has a fixed and definite dew-point or temperature of saturation.

If a cubic foot of air at a temperature of 87°, containing 4.076 grains per cubic foot with the wet-bulb temperature at 65°, is passed through a fine spray of recirculated water, it will absorb moisture; the dry-bulb temperature will immediately begin to fall, but the wet-bulb temperature will remain absolutely constant at 65° until the dry-bulb temperature has dropped to the wet-bulb temperature, namely, 65°. As the absorption takes place the dew-point will be gradually rising from 50° to 65°, when saturation is obtained. At ordinary temperatures the absorption of one grain of moisture per cu. ft. lowers the dry-bulb temperature approximately 8½°.

Sensible, Latent and Total Heat

The total heat of air is composed of the sensible heat or heat due to the temperature of the air as indicated by the thermometer, and the latent heat or heat of vaporization of the moisture or vapor in the air. The total heat is a constant quantity for any certain wet-bulb temperature irrespective of any change in the dry-bulb temperature. This fact has been termed by W. H. Carrier* "One of the four fundamental psychrometric principles," and expressed as

> **"The true wet-bulb temperature of the air depends entirely on the total of the sensible and the latent heat in the air and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant."**

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*"Rational Psychrometric Formulae" Am. Soc. Mech. Engrs., Dec., 1911.

Thus, if sufficient moisture is introduced into a certain quantity of air, the dry-bulb temperature of the air will be lowered until it is the same as the wet-bulb temperature. This is simply an exchange from sensible heat into latent heat required to vaporize the moisture, keeping the total heat the same. If a further lowering of the temperature takes place, the wet-bulb temperature will lower and the corresponding total heat will be less. If the air should be heated without the addition of more moisture, the dew-point temperature of the air would remain constant but the wet-bulb, as well as the dry-bulb temperature would increase, and the total heat of the air would increase a corresponding amount. The two psychrometric charts on pages 36 and 37 will be found especially convenient for determining the total heat of the air for any wet-bulb temperature.

Psychrometric Charts and Tables

Psychrometric charts giving the properties of air as calculated by W. H. Carrier and published in his paper entitled "Rational Psychrometric Formulae," which was presented before the A. S. M. E. at the 1911 annual meeting, are shown on pages 36 and 37. These two charts are to be used when calculations are being made in terms of pounds of air, while the chart on page 35 should be used for cubic feet of air. For most purposes of calculation it will be found preferable to use the pound as a unit.

The various curves shown on these charts will be found especially valuable in making air calculations. The grains of moisture per pound of dry air are read by passing directly from the **dew-point,** or intersection of the wet- and dry-bulb temperatures, to the scale on the left edge of the chart. The B. t. u. required to raise one pound of dry air one degree when saturated with moisture, as also the vapor pressure, may be determined by passing vertically from the dew-point to the proper curve, and then to the corresponding scale on the left edge of the chart. The total heat, in B. t. u., above zero degrees contained in one pound of dry air saturated with moisture may be found by passing vertically from the wet-bulb temperature to the total heat curve and then to the left edge of the chart. The volume of air in cubic feet per pound may be found by passing vertically from the dry-bulb temperature to either of the two volume curves and then to the left edge of the chart. One curve gives the volume of dry and the other of saturated air.

Example. As an example of the use of this chart we will assume air at 75° dry-bulb temperature and 60 per cent. relative humidity. From the chart we find that the wet-bulb temperature will be 65.25°, the dew-point 60°, the grains of moisture per pound of dry air 77; the heat required to raise one pound of dry air saturated at 60° through one degree is 0.24664 B. t. u.; and the vapor pressure of air saturated at 60° is 0.523 inches of mercury. Passing vertically from the wet-bulb temperature of 65.25° to the total heat curve and thence to the scale on the left, we find the total heat above zero in one pound of dry air when saturated at 65.25° to be 29.75 B. t. u. This, then, is also the measure of the heat in a pound of air at 75° and 60 per cent. relative humidity, since the wet-bulb temperature is the same.

The cubic feet per pound of air may be found by passing vertically from the dry-bulb temperature to either of the two volume curves, depending on whether the volume of dry or of saturated air is desired. To determine the volume of one pound of partly saturated air as here assumed, we will have from the chart,

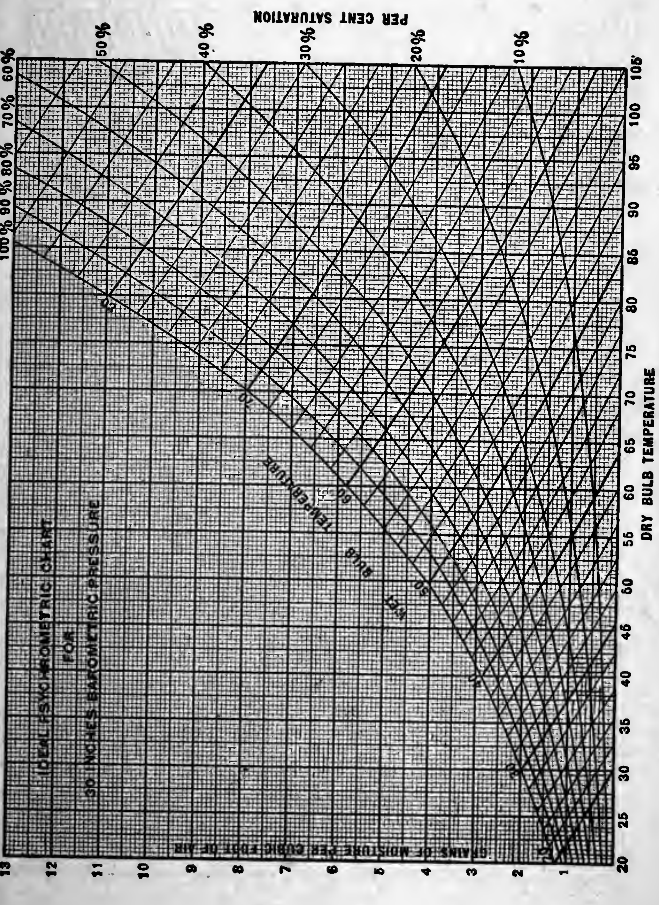
Cu. ft. per lb. at 75° sat. = 13.88
Cu. ft. per lb. at 75° dry = 13.48
.40 = Moisture
.60 = Rel. humidity
.24
13.48
Cu. ft. per lb. at 75° and 60% = 13.72

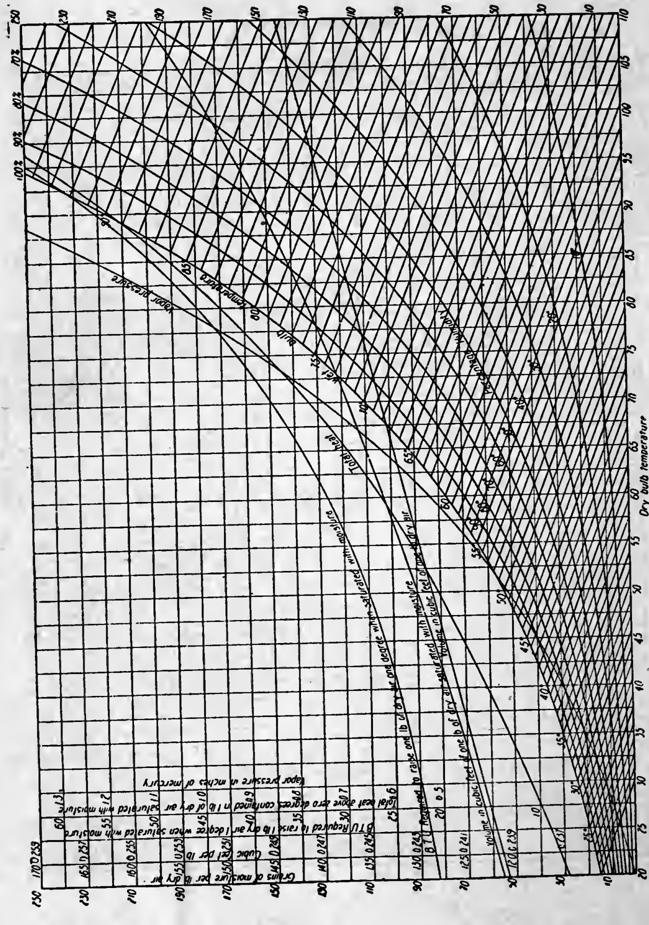
The psychrometric chart on page 35 and tables on pages 38 to 45 are taken from the catalog of the Carrier Air Conditioning Company of America. They show the grains of moisture per cubic foot of saturated air at various temperatures, as well as the relative humidity, the dew-point temperature and the grains of moisture per cubic foot of air for different temperatures as determined by the wet and dry-bulb of the sling psychrometer.

As an example of the use of the chart on page 35 we will assume a case where the dry-bulb temperature is 80° and the wet-bulb thermometer reads 70°, or a 10° depression. From the intersection of the corresponding lines through these two temperatures we find the relative humidity to be 62 per cent. Passing horizontally to the left from this point of intersection to the wet-bulb temperature line (called the saturation curve) we find the dew-point temperature to be 64.5°. If the temperature of the air should be reduced, both the dry and wet-bulb readings will be lowered until they both read 64.5°, when the air will be saturated. The grains of moisture contained in each cubic foot of this air will be found by continuing to the left on the horizontal line through the 64.5° dew-point to the left edge of the chart, where we have a reading of 6.65 grains. If the temperature of the air be further reduced, part of the moisture content will be condensed, the dew-point or saturation temperature will be lowered, and the grains of moisture per cubic foot will be correspondingly less.

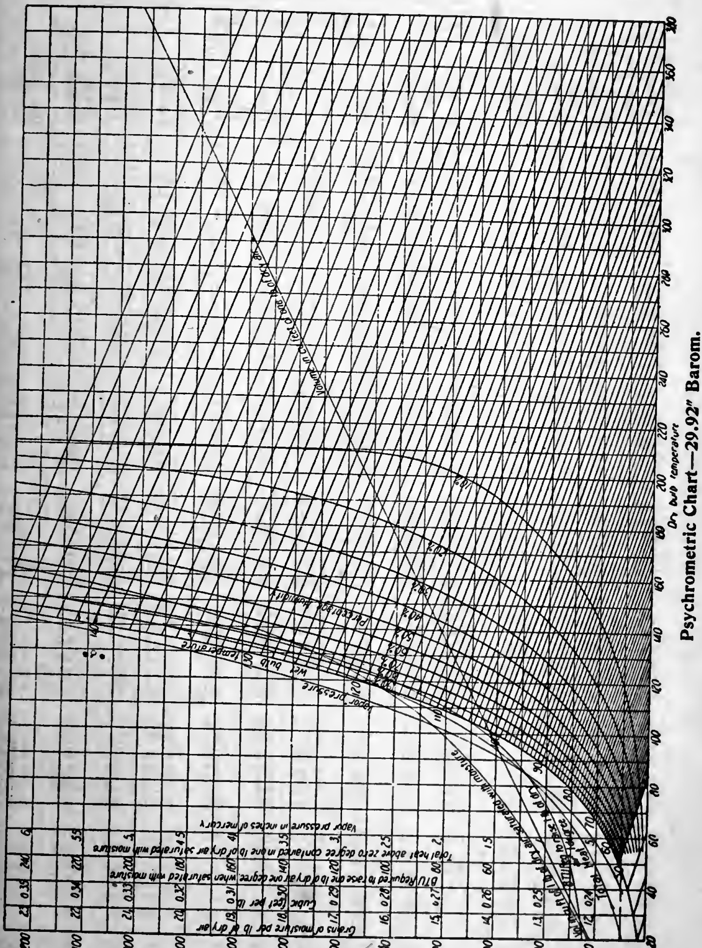
In case more accurate readings are desired than can be determined from a chart on as small a scale as the one on page 35, the psychrometric tables may be used.

NOTE.—Large psychrometric charts as shown on pages 36 and 37, with sub-divisions for accurate readings, will be furnished on request by the Carrier Air Conditioning Company of America, 39 Cortlandt St., New York City.


IDEAL PSYCHROMETRIC CHART
FOR
30 INCHES BAROMETRIC PRESSURE
PER CENT SATURATION
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
DRY BULB TEMPERATURE
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
GRAINS OF MOISTURE PER CUBIC FOOT OF AIR
1
2
3
4
5
6
7
8
9
10
11
12
13
WET BULB TEMPERATURE
20
30
40
50
60
70
80



Psychrometric Chart—29.92" Barom.



Psychrometric Chart—29.92" Barom.

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	Degrees Wet-Bulb Depression											
		1°			2°			3°			4°		
		% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
0	.48	67	–7	.32	33	–20	.16						
2	.53	70	–5	.37	39	–15	.21	9	–40	.05			
4	.58	72	–2	.42	44	–11	.26	17	–28	.10			
6	.64	74	0	.47	49	–8	.32	23	–21	.15			
8	.70	76	3	.54	53	–5	.37	29	–15	.20	6	–42	.04
10	.78	78	5	.61	56	–2	.44	34	–10	.26	13	–27	.11
12	.86	80	7	.69	59	2	.51	39	–6	.33	19	–19	.16
14	.94	81	10	.76	62	5	.58	44	–2	.41	26	–12	.25
16	1.03	82	12	.85	65	7	.65	48	+1	.50	31	–7	.32
18	1.13	84	14	.95	68	10	.72	52	5	.59	36	–2	.41
20	1.24	85	16	1.10	70	12	.86	55	8	.68	40	+2	.49
22	1.36	86	19	1.17	71	15	.96	58	11	.79	44	5	.60
24	1.48	87	21	1.30	73	17	1.10	60	13	.89	47	9	.70
26	1.62	87	23	1.41	75	20	1.22	63	16	1.02	51	12	.83
28	1.77	88	25	1.56	76	22	1.37	65	19	1.15	54	15	.96
30	1.94	89	27	1.72	78	25	1.50	67	21	1.30	56	18	1.08
32	2.11	89	30	1.88	79	27	1.67	69	24	1.46	59	21	1.25
34	2.28	90	32	2.05	81	29	1.85	71	26	1.62	62	23	1.41
36	2.46	91	34	2.24	82	31	2.02	73	29	1.79	64	26	1.57
38	2.65	91	36	2.41	83	33	2.20	75	31	1.98	66	28	1.74
40	2.85	92	38	2.62	83	35	2.36	75	33	2.14	68	30	1.94
42	3.06	92	40	2.82	85	38	2.61	77	35	2.36	69	33	2.12
44	3.29	93	42	3.06	85	40	2.80	78	37	2.57	71	35	2.34
46	3.54	93	44	3.29	86	42	3.04	79	40	2.80	72	37	2.54
48	3.80	93	46	3.53	86	44	3.27	79	42	3.00	73	40	2.77
50	4.08	93	48	3.79	87	46	3.55	80	44	3.26	74	42	3.02
52	4.37	94	50	4.11	87	48	3.80	81	46	3.54	75	44	3.28
54	4.69	94	52	4.40	88	50	4.13	82	48	3.84	76	46	3.56
56	5.02	94	54	4.71	88	53	4.41	82	51	4.11	76	49	3.81
58	5.37	94	56	5.05	88	55	4.73	83	53	4.46	77	51	4.14
59	5.56	94	57	5.22	89	56	4.95	83	54	4.61	78	52	4.33
60	5.75	94	58	5.40	89	57	5.11	83	55	4.77	78	53	4.48
61	5.94	94	59	5.58	89	58	5.29	84	56	4.99	78	54	4.64
62	6.14	94	60	5.77	89	59	5.46	84	57	5.16	79	55	4.85
63	6.35	95	61	6.03	89	60	5.65	84	58	5.23	79	56	5.01
64	6.56	95	62	6.24	90	61	5.91	84	59	5.51	79	57	5.19
65	6.78	95	63	6.44	90	62	6.10	85	60	5.77	80	59	5.43
66	7.01	95	64	6.66	90	63	6.31	85	61	5.96	80	60	5.61
67	7.24	95	65	6.88	90	64	6.52	85	62	6.16	80	61	5.79
68	7.48	95	67	7.10	90	65	6.73	85	63	6.36	80	62	5.98
69	7.73	95	68	7.34	90	66	6.95	85	64	6.57	81	63	6.26
70	7.98	95	69	7.58	90	67	7.18	86	65	6.86	81	64	6.46
71	8.24	95	70	7.83	90	68	7.42	86	67	7.09	81	65	6.67
72	8.51	95	71	8.08	91	69	7.74	86	68	7.31	82	66	6.97
73	8.78	95	72	8.34	91	70	7.99	86	69	7.55	82	67	7.20
74	9.07	95	73	8.61	91	71	8.25	86	70	7.80	82	68	7.43
75	9.36	96	74	8.89	91	72	8.51	86	71	8.05	82	69	7.67
76	9.66	96	75	9.27	91	73	8.79	87	72	8.40	82	70	7.92

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT—Barometric Pressure, 30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	1°			2°			3°			4°		
		% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
77	9.96	96	76	9.56	91	74	9.02	87	73	8.67	83	71	8.27
78	10.28	96	77	9.87	91	75	9.35	87	74	8.94	83	72	8.53
79	10.60	96	78	10.18	91	76	9.65	87	75	9.21	83	73	8.80
80	10.93	96	79	10.50	91	77	9.95	87	76	9.51	83	74	9.08
81	11.28	96	80	10.82	92	78	10.37	88	77	9.92	84	75	9.47
82	11.63	96	81	11.16	92	79	10.70	88	78	10.23	84	77	9.77
83	11.99	96	82	11.51	92	80	11.03	88	79	10.55	84	78	10.07
84	12.36	96	83	11.86	92	81	11.37	88	80	10.87	84	79	10.38
85	12.74	96	84	12.22	92	82	11.72	88	81	11.21	84	80	10.70
86	13,13	96	85	12.60	92	83	12.08	88	82	11.55	84	81	11.03
87	13.53	96	86	12.99	92	84	12.44	88	83	11.90	85	82	11.50
88	13.94	96	87	13.38	92	85	12.82	88	84	12.26	85	83	11.85
89	14.36	96	88	13.99	92	86	13.21	88	85	12.64	85	84	12.21
90	14.79	96	89	14.20	92	87	13.61	89	86	13.16	85	85	12.57
92	15.69	96	91	15.06	92	89	14.44	89	88	13.96	85	87	13.34
94	16.63	96	93	15.97	93	92	15.47	89	90	14.81	85	89	14.14
96	17.63	96	95	16.92	93	94	16.39	89	92	15.69	86	91	15.16
98	18.67	96	97	17.92	93	96	17.36	89	94	16.62	86	93	16.06
100	19.77	96	99	18.98	93	98	18.38	89	96	17.59	86	95	17.00
104	22.13	97	103	21.46	93	102	20.58	90	100	19.91	87	99	19.25
108	24.72	97	107	23.98	93	106	22.99	90	104	22.25	87	103	21.51
112	27.88	97	111	27.02	94	110	26.19	90	109	25.07	87	107	24.24
116	30.10	97	115	29.20	94	114	28.29	91	113	27.39	88	111	27.21
120	34.80	97	119	33.76	94	118	32.71	91	117	31.67	88	115	30.62

Dry-Bulb Temp.	Grains per Cu. Ft. at Saturation	5°			6°			7°			8°		
		% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
20	1.24	26	–7	.32	12	–21	.15						
22	1.36	31	–2	.42	17	–12	.23	4	–36	.05			
24	1.48	35	+2	.52	22	–6	.33	10	–20	.15			
26	1.62	39	7	.63	27	–1	.44	16	–11	.26	4	–32	.07
28	1.77	43	10	.76	32	+4	.52	21	–4	.37	10	–17	.18
30	1.94	46	14	.89	36	8	.70	26	+2	.50	16	–7	.31
32	2.11	49	17	1.03	39	12	.82	30	7	.63	20	–1	.42
34	2.28	52	20	1.19	43	16	.98	34	11	.78	25	5	.57
36	2.46	55	23	1.35	46	19	1.13	38	15	.93	29	10	.71
38	2.65	58	25	1.54	50	22	1.32	42	18	1.11	33	14	.87
40	2.85	60	28	1.71	52	25	1.48	45	21	1.28	37	18	1.06
42	3.06	62	30	1.90	55	27	1.69	47	24	1.44	40	21	1.23
44	3.29	63	32	2.08	56	30	1.85	49	27	1.61	43	24	1.42
46	3.54	65	35	2.30	58	32	2.05	52	29	1.84	45	27	1.59
48	3.80	66	37	2.51	60	35	2.28	54	32	2.05	47	29	1.79
50	4.08	67	40	2.73	61	37	2.49	55	34	2.24	49	32	1.98

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

	Degrees Wet-Bulb Depression											
	5°			6°			7°			8°		
Dry-Bulb Temp.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
52	69	42	3.02	63	40	2.75	57	37	2.49	51	34	2.23
54	70	44	3.28	64	42	3.00	59	40	2.77	53	37	2.48
56	71	47	3.61	65	44	3.26	60	42	3.01	55	40	2.76
58	72	49	3.87	66	47	3.55	61	45	3.28	56	42	3.01
59	72	50	4.00	67	48	3.72	62	46	3.44	57	44	3.17
60	73	51	4.19	68	49	3.91	63	47	3.62	58	45	3.33
61	73	52	4.34	68	50	4.04	63	48	3.74	58	46	3.45
62	74	53	4.54	69	52	4.24	64	50	3.93	59	47	3.62
63	74	55	4.71	69	53	4.38	64	51	4.07	60	49	3.81
64	74	56	4.86	70	54	4.59	65	52	4.27	60	50	3.94
65	75	57	5.09	70	55	4.75	66	53	4.48	61	51	4.14
66	75	58	5.26	71	56	4.98	66	54	4.63	61	52	4.28
67	75	59	5.43	71	57	5.14	66	55	4.78	62	53	4.49
68	76	60	5.69	71	58	5.31	67	57	5.01	62	55	4.64
69	76	61	5.87	72	59	5.56	67	58	5.18	63	56	4.87
70	77	62	6.15	72	61	5.75	68	59	5.43	64	57	5.11
71	77	63	6.35	72	62	5.93	68	60	5.60	64	58	5.27
72	77	64	6.55	73	63	6.21	69	61	5.87	65	59	5.53
73	78	66	6.85	73	64	6.41	69	62	6.06	65	60	5.71
74	78	67	7.07	74	65	6.71	69	63	6.26	65	62	5.89
75	78	68	7.30	74	66	6.92	70	64	6.59	66	63	6.18
76	78	69	7.53	74	67	7.14	70	66	6.76	66	64	6.37
77	79	70	7.87	74	68	7.37	71	67	7.07	67	65	6.67
78	79	71	8.12	75	69	7.71	71	68	7.30	67	66	6.89
79	79	72	8.38	75	70	7.95	71	69	7.53	68	67	7.21
80	79	73	8.64	75	72	8.20	72	70	7.87	68	68	7.44
81	80	74	9.02	76	73	8.57	72	71	8.12	69	70	7.78
82	80	75	9.30	76	74	8.84	72	72	8.37	69	71	8.02
83	80	76	9.59	76	75	9.11	73	73	8.75	69	72	8.27
84	80	77	9.89	76	76	9.39	73	74	9.02	69	73	8.53
85	81	78	10.32	77	77	9.81	73	75	9.30	70	74	8.92
86	81	79	10.63	77	78	10.11	73	76	9.58	70	75	9.19
87	81	80	10.96	77	79	10.42	74	78	10.01	70	76	9.47
88	81	81	11.29	77	80	10.73	74	79	10.31	70	77	9.76
89	81	82	11.63	78	81	11.20	74	80	10.63	71	78	10.19
90	81	83	11.98	78	82	11.54	74	81	10.94	71	79	10.50
92	82	86	12.87	78	84	12.24	75	83	11.77	72	81	11.30
94	82	88	13.64	79	86	13.14	75	85	12.48	72	84	11.98
96	82	90	14.45	79	88	13.93	76	87	13.40	73	86	12.87
98	83	92	15.50	79	90	14.75	76	89	14.19	73	88	13.63
100	83	94	16.41	80	93	15.81	77	91	15.22	73	90	14.43
104	83	98	18.36	80	97	17.70	77	95	17.04	74	94	16.37
108	84	102	20.77	81	101	20.02	78	100	19.28	75	98	18.54
112	84	106	23.40	81	105	22.57	79	104	21.60	76	103	20.90
116	85	110	26.31	82	109	25.40	79	108	24.50	76	107	23.60
120	85	114	29.58	82	113	28.88	80	112	27.84	77	111	26.78

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Dry-Bulb Temp.	Degrees Wet-Bulb Depression 9°			10°			11°			12°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
40	29	13	0.83	22	7	0.63	15	−1	0.43	7	−14	0.20
42	33	17	1.01	26	12	0.80	19	6	0.58	12	−3	0.37
44	36	20	1.19	30	16	0.99	23	11	0.76	16	4	0.53
46	39	23	1.38	32	20	1.13	26	15	0.92	20	10	0.71
48	41	26	1.56	35	23	1.33	29	19	1.11	23	14	0.88
50	43	29	1.75	38	26	1.55	32	22	1.30	27	18	1.10
52	46	32	2.01	40	29	1.75	35	26	1.53	29	22	1.27
54	48	34	2.25	42	32	1.97	37	29	1.73	32	25	1.49
56	50	37	2.51	44	34	2.21	39	32	1.96	34	29	1.71
58	51	40	2.74	46	37	2.47	41	35	2.20	37	32	1.99
60	53	43	3.04	48	40	2.76	43	38	2.47	39	35	2.25
62	54	45	3.32	50	43	3.07	45	40	2.76	41	38	2.52
64	56	48	3.68	51	46	3.35	47	43	3.09	43	41	2.82
66	57	50	3.99	53	48	3.71	48	46	3.36	44	44	3.08
67	58	52	4.20	53	49	3.84	49	47	3.55	45	45	3.19
68	58	53	4.34	54	51	4.04	50	49	3.74	46	46	3.44
69	59	54	4.56	55	52	4.25	51	50	3.94	47	48	3.63
70	59	55	4.71	55	53	4.39	51	51	4.07	48	49	3.83
71	60	56	4.94	56	54	4.62	52	52	4.29	48	50	3.96
72	61	58	5.19	57	56	4.86	53	54	4.51	49	52	4.17
73	61	59	5.36	57	57	5.01	53	55	4.65	50	53	4.39
74	61	60	5.53	58	58	5.26	54	56	4.90	50	54	4.53
75	62	61	5.80	58	59	5.43	54	57	5.05	51	55	4.77
76	62	62	5.99	59	60	5.70	55	59	5.31	51	57	4.92
77	63	63	6.28	59	62	5.88	56	60	5.58	52	58	5.18
78	63	64	6.47	60	63	6.17	56	61	5.76	53	59	5.45
79	64	66	6.79	60	64	6.36	57	62	6.04	53	60	5.62
80	64	67	7.00	61	65	6.67	57	63	6.23	54	62	5.90
81	65	68	7.33	61	66	6.88	58	65	6.54	55	63	6.20
82	65	69	7.56	61	67	7.09	58	66	6.74	55	64	6.39
83	66	70	7.91	62	69	7.43	59	67	7.07	56	65	6.71
84	66	71	8.16	62	70	7.66	59	68	7.29	56	66	6.92
85	66	72	8.41	63	71	8.02	60	69	7.64	57	68	7.26
86	66	73	8.67	63	72	8.27	60	70	7.88	57	69	7.48
87	67	75	9.06	64	73	8.66	61	72	8.25	57	70	7.71
88	67	76	9.34	64	74	8.92	61	73	8.50	57	71	7.94
89	68	77	9.76	65	75	9.33	61	74	8.76	58	72	8.33
90	68	78	10.06	65	76	9.61	61	75	9.09	58	73	8.58
92	68	80	10.67	65	79	10.20	62	77	9.73	59	76	9.26
94	69	82	11.48	66	81	10.98	63	79	10.48	60	78	9.98
96	69	84	12.16	66	83	11.63	63	82	11.11	61	80	10.75
98	70	87	13.07	67	85	12.51	64	84	11.95	61	82	11.39
100	70	89	13.84	68	87	13.44	65	86	12.85	62	85	12.26
104	71	93	15.71	69	92	15.27	66	90	14.60	63	89	13.94
108	72	97	17.80	70	96	17.30	67	95	16.56	64	93	15.82
112	73	101	20.34	70	100	19.50	68	99	18.94	65	98	18.11
116	74	105	22.99	71	104	22.05	69	103	21.45	66	102	20.55
120	74	110	25.71	72	108	25.01	69	107	23.95	67	106	23.24

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	13°			14°			15°			16°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
50	21	13	0.86	16	8	0.65	10	0	0.41	5	−13	0.20
52	24	18	1.05	19	13	0.83	14	7	0.61	9	−2	0.39
54	27	22	1.27	22	18	1.03	17	12	0.80	12	6	0.56
56	30	25	1.51	25	22	1.25	20	17	1.00	16	12	0.80
58	32	29	1.72	27	25	1.45	23	21	1.24	18	17	0.97
59	33	30	1.83	29	27	1.61	24	23	1.33	20	19	1.11
60	34	32	1.95	30	29	1.72	26	25	1.50	21	21	1.21
61	35	33	2.08	31	30	1.84	27	27	1.60	22	23	1.31
62	36	35	2.21	32	32	1.97	28	29	1.72	24	25	1.47
63	37	36	2.34	33	34	2.17	29	30	1.84	25	27	1.59
64	38	38	2.49	34	35	2.23	30	32	1.97	26	29	1.71
65	39	40	2.65	35	37	2.37	31	34	2.10	27	31	1.83
66	40	41	2.80	36	38	2.52	32	35	2.24	29	32	2.03
67	41	43	2.97	37	40	2.68	33	37	2.39	30	34	2.17
68	42	44	3.14	38	42	2.84	34	39	2.54	31	36	2.32
69	43	45	3.32	39	43	3.01	35	40	2.70	32	37	2.47
70	44	47	3.51	40	44	3.19	36	42	2.87	33	39	2.63
71	45	48	3.71	41	46	3.38	37	43	3.05	33	41	2.72
72	45	50	3.83	42	47	3.57	38	45	3.23	34	42	2.89
73	46	51	4.04	42	49	3.69	39	46	3.43	35	44	3.07
74	47	52	4.26	43	50	3.90	39	48	3.54	36	45	3.26
75	47	54	4.40	44	51	4.12	40	49	3.74	37	47	3.46
76	48	55	4.64	44	53	4.25	41	51	3.96	38	48	3.67
77	48	56	4.78	45	54	4.48	42	52	4.18	39	50	3.89
78	49	57	5.04	46	55	4.73	43	53	4.42	39	51	4.01
79	50	59	5.30	46	57	4.88	43	55	4.56	40	53	4.24
80	50	60	5.47	47	58	5.14	44	56	4.81	41	54	4.48
81	51	61	5.75	48	59	5.41	45	57	5.07	42	55	4.74
82	51	62	5.93	48	60	5.58	45	59	5.23	42	57	4.88
83	52	64	6.23	49	62	5.87	46	60	5.52	43	58	5.01
84	52	65	6.43	49	63	6.06	46	61	5.68	43	59	5.31
85	53	66	6.75	50	64	6.37	47	62	5.99	44	61	5.60
86	53	67	6.96	50	65	6.56	47	64	6.17	44	62	5.78
87	54	68	7.17	51	67	6.90	48	65	6.49	46	63	6.22
88	54	69	7.53	51	68	7.11	48	66	6.69	46	64	6.41
89	55	71	7.90	52	69	7.47	49	67	7.04	47	66	6.75
90	55	72	8.13	52	70	7.69	49	69	7.25	47	67	6.95
92	56	74	8.79	53	73	8.32	50	71	7.84	48	69	7.53
94	57	76	9.48	54	75	8.98	51	73	8.48	49	72	8.15
96	58	79	10.22	55	77	9.69	52	76	9.17	50	74	8.81
98	58	81	10.83	56	79	10.46	53	78	9.90	50	76	9.34
100	59	83	11.66	56	82	11.07	54	80	10.67	51	79	10.08
104	60	88	13.28	58	86	12.83	55	85	12.17	53	83	11.73
108	62	92	15.33	59	91	14.59	57	89	14.09	54	88	13.35
112	63	96	17.55	60	95	16.72	58	94	16.16	55	92	15.39
116	64	101	19.95	61	99	19.05	59	98	18.45	57	97	17.85
120	65	105	22.40	62	104	21.46	60	102	20.75	58	101	20.07

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	17°			18°			19°			20°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
52	4	−17	0.18									
54	8	−4	0.38	3	−20	0.14						
56	11	5	0.55	7	−5	0.35	2	−25	0.10			
58	14	11	0.75	10	4	0.54	6	−6	0.32	1	−30	0.05
59	16	14	0.89	11	8	0.61	7	0	0.42	3	−20	0.14
60	17	17	0.98	13	11	0.75	9	4	0.52	5	−8	0.29
61	18	19	1.07	14	14	0.83	10	8	0.63	6	−1	0.39
62	20	21	1.23	16	16	0.98	12	11	0.74	8	3	0.49
63	21	23	1.33	17	19	1.08	14	14	0.86	10	7	0.60
64	22	25	1.44	18	21	1.18	15	17	0.98	11	11	0.72
65	24	27	1.63	20	24	1.36	16	19	1.09	13	14	0.86
66	25	29	1.75	21	26	1.47	17	22	1.19	14	17	0.98
67	26	31	1.88	22	28	1.59	18	24	1.35	15	19	1.09
68	27	33	2.00	23	29	1.72	20	26	1.50	16	22	1.20
69	28	34	2.16	24	31	1.85	21	28	1.63	17	24	1.36
70	29	36	2.31	25	33	2.00	22	30	1.76	19	26	1.52
71	30	38	2.47	27	35	2.23	23	32	1.85	20	28	1.66
72	31	40	2.64	28	37	2.38	24	33	2.04	21	30	1.79
73	32	41	2.81	29	38	2.55	25	35	2.20	22	32	1.94
74	33	43	2.99	29	40	2.63	26	37	2.36	23	34	2.09
75	34	44	3.18	30	42	2.81	27	39	2.53	24	36	2.25
76	34	46	3.28	31	43	2.99	28	41	2.70	25	38	2.41
77	35	48	3.49	32	45	3.19	29	42	2.89	26	39	2.59
78	36	49	3.70	33	46	3.39	30	44	3.08	27	41	2.78
79	37	50	3.92	34	48	3.60	31	46	3.29	28	43	2.97
80	38	52	4.16	35	50	3.83	32	47	3.50	29	44	3.17
81	39	53	4.40	36	51	4.06	33	49	3.72	30	46	3.38
82	39	55	4.53	36	52	4.19	33	50	3.84	30	48	3.49
83	40	56	4.65	37	54	4.44	34	52	4.08	31	49	3.72
84	40	57	4.94	37	55	4.57	35	53	4.33	32	51	3.95
85	41	59	5.22	38	57	4.84	36	54	4.59	33	52	4.20
86	42	60	5.52	39	58	5.12	36	56	4.73	33	54	4.33
87	43	61	5.82	40	59	5.41	37	57	5.00	34	55	4.60
88	43	62	5.99	40	61	5.58	37	59	5.16	35	57	4.88
89	44	64	6.32	41	62	5.89	38	60	5.46	36	58	5.17
90	44	65	6.51	41	63	6.06	39	61	5.77	36	59	5.33
92	45	68	7.06	42	66	6.59	40	64	6.28	37	62	5.81
94	46	70	7.65	43	68	7.15	41	67	6.82	38	65	6.32
96	47	72	8.28	44	71	7.76	42	69	7.40	39	67	6.87
98	48	75	8.96	45	73	8.40	43	72	8.03	40	70	7.47
100	49	77	9.69	46	76	9.09	44	74	8.70	41	72	8.10
104	50	82	11.06	48	80	10.62	46	79	10.18	43	77	9.51
108	52	86	12.85	49	85	12.11	47	84	11.62	45	82	11.12
112	53	91	14.84	51	90	14.28	49	88	13.70	47	87	13.12
116	54	95	16.87	52	94	16.21	50	93	15.62	48	91	14.98
120	55	100	19.05	53	98	18.37	51	97	17.69	49	96	16.96

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	21°			22°			23°			24°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
66	10	11	0.70	7	2	0.49	3	-11	0.21	0		
68	13	17	0.97	10	11	0.75	6	2	0.45	3	-11	0.22
70	15	22	1.20	12	17	0.96	9	11	0.72	6	2	0.48
72	18	26	1.53	15	22	1.28	12	17	1.02	9	11	0.77
74	20	30	1.81	17	27	1.54	14	23	1.27	11	18	1.00
75	21	32	1.96	18	29	1.68	15	25	1.40	12	21	1.12
76	22	34	2.12	19	31	1.84	16	27	1.55	13	23	1.26
77	23	36	2.29	20	33	1.99	17	29	1.69	14	26	1.39
78	24	38	2.47	21	35	2.16	18	31	1.85	16	28	1.64
79	25	40	2.65	22	37	2.33	19	34	2.01	17	30	1.80
80	26	42	2.74	23	39	2.52	20	36	2.19	18	32	1.97
81	27	43	3.04	24	41	2.71	21	38	2.37	19	34	2.14
82	28	45	3.26	25	42	2.91	22	39	2.56	20	36	2,33
83	29	47	3.48	26	44	3.12	23	41	2.76	21	38	2.52
84	29	48	3.58	26	46	3.31	24	43	2.97	21	40	2.59
85	30	50	3.82	27	48	3.44	25	45	3.18	22	42	2.80
86	31	52	4.07	28	49	3.68	26	47	3.41	23	44	3.02
87	32	53	4.33	29	51	3.92	26	48	3.52	24	46	3.25
88	32	55	4.46	30	52	4.18	27	50	3.76	25	47	3.48
89	33	56	4.74	31	54	4.45	28	51	4.02	26	49	3.73
90	34	57	5.03	31	55	4.59	29	53	4.29	26	51	3.85
92	35	60	5.49	32	58	5.02	30	56	4.71	28	54	4.39
94	36	63	5.99	33	61	5.49	31	59	5.16	29	57	4.82
96	37	66	6.52	35	64	6.17	32	62	5.64	30	60	5.29
98	38	68	7.10	36	66	6.72	34	64	6.35	32	63	5.98
100	39	71	7.71	37	69	7.31	35	67	6.92	33	65	6.52
104	41	76	9.07	39	74	8.63	37	72	8.19	35	71	7.75
108	43	81	10.63	41	79	10.14	39	77	9.64	37	76	9.15
112	44	85	12.26	42	84	11.68	40	82	11.10	38	81	10.54
116	46	90	14.33	44	88	13.69	42	87	13.04	40	86	12.40
120	47	94	16.28	45	93	15.60	43	92	14.92	41	90	14.24

Dry-Bulb Temp.	25°			26°			27°			28°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
75	9	15	0.84	7	8	0.66	4	-2	0.37	1	-23	0.09
76	11	18	1.06	8	12	0.77	5	4	0.48	3	-10	0.29
77	12	21	1.20	9	16	0.90	6	9	0.60	4	-2	0.40
78	13	24	1.34	10	19	1.03	8	13	0.82	5	5	0.51
79	14	26	1.48	11	22	1.17	9	16	0.95	6	10	0.64
80	15	28	1.64	12	24	1.31	10	20	1.09	7	13	0.77
81	16	31	1.80	13	27	1.47	11	22	1.24	9	17	1.02
82	17	33	1.98	14	29	1.63	12	25	1.40	10	20	1.16
83	18	35	2.16	15	31	1.80	13	27	1.56	11	23	1.32

RELATIVE HUMIDITY, DEW-POINTS AND GRAINS OF MOISTURE PER CUBIC FOOT

Barometric Pressure—30 Inches

Degrees Wet-Bulb Depression

Dry-Bulb Temp.	25°			26°			27°			28°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
84	19	37	2.35	16	34	1.98	14	30	1.73	12	26	1.48
85	20	39	2.55	17	36	2.17	15	32	1.91	13	28	1.66
86	21	41	2.76	18	38	2.36	16	34	2.10	14	31	1.84
87	22	43	2.98	19	40	2.57	17	36	2.30	15	33	2.03
88	22	45	3.07	20	42	2.79	18	38	2.51	15	35	2.09
89	23	46	3.30	21	44	3.02	19	41	2.73	16	37	2.30
90	24	48	3.55	22	45	3.25	19	43	2.81	17	39	2.52
92	25	51	3.92	23	49	3.61	21	46	3.30	19	43	2.98
94	27	55	4.49	24	52	3.99	22	50	3.66	20	47	3.33
96	28	58	4.94	26	55	4.58	24	53	4.23	22	51	3.88
98	29	61	5.41	27	58	5.04	25	56	4.67	23	54	4.29
100	30	63	5.93	28	61	5.54	26	59	5.14	24	57	4.74
104	33	69	7.30	31	67	6.86	29	65	6.42	27	63	5.98
108	35	74	8.65	33	72	8.16	31	71	7.66	29	69	7.17
112	36	79	9.98	35	78	9.42	33	76	8.86	31	74	8.58
116	38	84	11.78	36	83	11.16	34	81	10.56	33	79	10.25
120	40	89	13.90	38	87	13.20	36	86	12.49	34	84	11.79

Dry-Bulb Temp.	29°			30°			31°			32°		
	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.	% Rel. Hum.	Dew-Point	Grs. per Cu. Ft.
78	3	−9	0.31									
79	4	−1	0.42	1	−20	0.11						
80	5	6	0.55	3	−7	0.33						
81	6	10	0.68	4	0	0.45	1	−18	0.11			
82	7	14	0.81	5	7	0.58	2	−6	0.23	0		
83	8	18	0.96	6	11	0.72	3	2	0.36	2	−15	0.24
84	9	21	1.11	7	15	0.87	5	8	0.62	3	−4	0.37
85	10	24	1.27	8	19	1.02	6	12	0.77	4	3	0.51
86	11	27	1.44	9	22	1.18	7	16	0.92	5	9	0.66
87	12	29	1.62	10	25	1.35	8	20	1.08	6	13	0.81
88	13	31	1.81	11	27	1.53	9	23	1.26	7	17	0.98
89	14	34	2.01	12	30	1.72	10	26	1.44	8	21	1.15
90	15	36	2.22	13	32	1.92	11	28	1.63	9	24	1.33
92	17	40	2.67	15	37	2.35	13	33	2.04	11	29	1.73
94	18	44	2.99	16	41	2.66	14	38	2.33	12	34	2.00
96	20	48	3.53	18	45	3.17	16	42	2.82	14	39	2.47
98	21	52	3.92	19	49	3.55	17	46	3.17	15	43	2.80
100	22	55	4.35	21	52	4.15	19	50	3.76	17	47	3.36
104	25	61	5.53	23	59	5.09	21	57	4.65	20	54	4.43
108	27	67	6.67	25	65	6.18	24	63	5.93	22	61	5.44
112	29	72	8.03	27	71	7.49	26	69	7.22	24	67	6.68
116	31	78	9.61	29	76	8.99	28	74	8.68	26	73	8.06
120	33	83	11.44	31	81	10.73	29	80	10.04	28	78	9.70

PART II

APPLICATION

The principles of Fan Engineering have found application for a great variety of purposes and an ever increasing use in the manufacturing industries. These applications will be briefly treated under their proper heading, such as Heating, Ventilation, Drying, Cooling, Mechanical Draft, Planing Mill and other exhaust systems and various other miscellaneous uses. Some of these applications, such as heating and ventilation, are so common as to be more or less familiar to all engineers, while others are of a more special nature and the requirements as well as the apparatus used are not so generally understood.

SECTION I

HEATING

Although the heating of buildings is accomplished in many ways, the fundamental requirements and the results desired are the same in all systems; that is, to provide sufficient heat to take care of the radiation and infiltration losses, and if required, to warm the air needed for ventilation.

Heat Losses from Buildings

The heating capacity depends on the amount of the heat losses, so evidently the first step in laying out any heating system is to determine the extent of these losses. The main source of loss will be due to radiation, and as accurate data in the form of factors or coefficients for the various building materials used are available, the total heat loss may be determined when the extent of the surface is known.

Each of the various materials used in building construction has a certain capacity for transmitting heat, or we may say exerts a certain resistance to the transmission of heat, and the transmission of heat may be shown to be the reciprocal of the resistance. This transmission is due to two components, radiation and convection from the surface, and conduction through the material. The radiation and convection factor is independent of the thickness, but varies with the height of the wall, with the difference in temperature between the two sides of the material, and with variation in the air movement or velocity over the surface. While for extreme accuracy all of these variables should be considered, for ordinary calculations we may use a coefficient which will meet the average conditions. We will represent this factor by NK; where N varies with the temperature difference according to the accompanying table, and K is a constant for any given material,

$NK =$ Surface transmission for each material.

$\frac{1}{NK} =$ Surface resistance to the transmission of heat by radiation and convection.

The conductivity of any material will vary with the thickness, so that we will have

$A =$ Conductivity of material itself from surface to surface per unit thickness.

$\frac{1}{A} =$ Resistance of the material per unit of thickness to the transmission of heat.

$W =$ Thickness of the material.

$\frac{A}{W} =$ Conductivity of the material.

$\frac{W}{A} =$ Resistance of the material to conduction.

$L =$ B. t. u. transmitted per sq. ft. per hour per deg. difference.

As the total resistance is composed of the two factors $\frac{1}{NK}$ and $\frac{W}{A}$, we have the transmission in B. t. u. per square foot per degree difference in temperature between the two sides of the material,

$$L = \frac{1}{\frac{1}{NK} + \frac{W}{A}} \tag{29}$$

and the total transmission per square foot per hour with temperatures t_1 and t_2 on the two sides of the material will be

$$L_1 = \frac{t_1 - t_2}{\frac{1}{NK} + \frac{W}{A}} = L\ (t_1 - t_2) \tag{30}$$

In case we are to consider a double wall or a wall made up of more than one material, we will have greater resistance due to the extra surfaces adding their resistances and also to the added resistances to conduction, thus giving a lower rate of heat transmission. This will then give us

$$L = \frac{1}{\left(\frac{1}{N_1K_1} + \frac{1}{N_2K_2} + \&c\right) + \left(\frac{W_1}{A_1} + \frac{W_2}{A_2} + \&c\right)} \qquad (31)$$

In case the materials considered are very thin, but slight error will be introduced if we neglect the conduction factor and consider only the resistance of the surface.

This theory of heat transmission was first deduced by Peclet and has been used by the majority of investigators for determining factors of heat transmission. The following values for N, K and A are adapted from the original tables of factors for use in these formulae. The values given for A are for a unit thickness of one inch.

VALUES OF N FOR VARIOUS TEMPERATURE DIFFERENCES

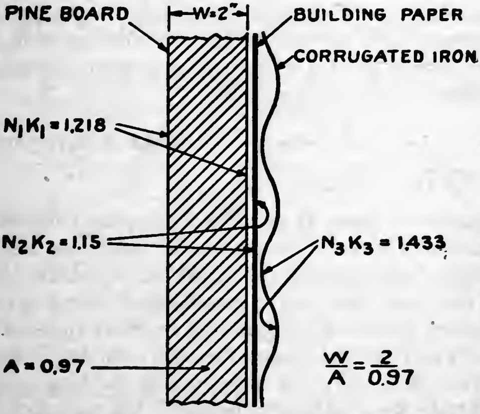
Difference Between Inside and Outside Temperature	N	Difference Between Inside and Outside Temperature	N
5	0.580	50	0.956
10	0.670	55	0.974
15	0.740	60	0.987
20	0.790	65	1.000
25	0.825	70	1.012
30	0.860	75	1.023
35	0.887	80	1.032
40	0.912	85	1.040
45	0.936	90	1.047

VALUES OF K AND A FOR DIFFERENT MATERIALS

Materials	K	A
Brick	1.275	5.50
Brick and 2″ Air space	0.460	5.50
Pine Board	1.275	0.97
Oak Board	1.275	1.75
Double Pine Board, Paper Between	0.475	0.97
Corrugated Iron	1.500	
Sheet Iron	1.200	224.00
Pine Board and Corrugated Iron	0.575	0.97
Pine Board and Sheet Iron	0.675	0.97
Single Glass	1.095	7.20
Double Glass	0.470	
Building Paper	1.200	

The values given in the above table apply to the two sides of the material considered, and would be double in case the factor for one side only is desired. That is, the resistance of only one surface would be one-half and the transmission therefore double the values given for the two surfaces. These factors as given apply to wall construction, where there is more or less movement of the air over the surfaces due to the current of air passing up the walls. With a roof or a floor this movement of the air will be greatly lessened and the transmission consequently decreased. The necessary modifications of the factors for other than wall construction are in a great measure a matter of judgment.

The application of the foregoing formula may best be shown by a practical example, in which it is required to determine the coefficient of transmission per square foot per degree difference in temperature for a wall composed of two-inch pine boards covered with building paper and corrugated iron, with a difference of 50° in temperature between the two sides. From the accompanying table we find the value of N to be 0.956.



HEAT TRANSMISSION THROUGH WALLS.

We will have six surface resistances to consider, N K for the two surfaces of the board being 1.218 and for the two surfaces of the corrugated iron 1.433. On account of the fact that the paper and the iron are quite thin the resistance to conduction would be very small and may be omitted for these two materials without serious error.

We will then have the surface resistance $\frac{1}{N_1K_1}=\frac{1}{1.218}$ for the two board surfaces, and assuming the same surface loss for paper as is given for sheet iron, we will have the resistance for the two sides of the paper $\frac{1}{N_2K_2}=\frac{1}{1.15}$

As already stated the resistance of the two surfaces of the iron will be $\frac{1}{N_3K_3}=\frac{1}{1.433}$ The resistance to conduction of the two-inch pine board will be $\frac{W}{A}=\frac{2}{0.97}$ Then we will have the total transmission in B. t. u. per sq. ft. per degree difference in temperature between the two sides of the wall as,

$$L=\frac{1}{\frac{1}{1.218}+\frac{1}{1.15}+\frac{1}{1.433}+\frac{2}{0.97}}=0.224 \text{ B. t. u. per hour.}$$

If we leave out the paper and consider a wall composed of two-inch boards and corrugated iron, the transmission in B. t. u. per sq. ft. of wall per degree difference in temperature between the two sides of the wall would be

$$L=\frac{1}{\frac{1}{1.218}+\frac{1}{1.433}+\frac{2}{0.97}}=0.279 \text{ B. t. u. per hour.}$$

The factors on pages 51 and 52 are compiled from the best authorities and will be found to agree with modern engineering practice. Much of our information on this subject dates back to the time of Peclet and other early investigators, but a great deal of work has been done more recently in an effort to obtain authentic data. The principal reason for discrepancies in this part of the work is due to the great difference in building construction. Thus, although as ordinarily considered, the radiation loss is the principal factor to be considered and reliable data is available, nevertheless, due to poor construction, the convection losses may become so great that the apparatus will be unable to furnish the heat required.

For this reason these factors are subject to modifications to care for special cases such as exposure to winds, unequal distribution of heat, infiltration of cold air, etc. The German government standards require these factors to be increased as follows:

Ten per cent. where the exposure is a northerly one and the winds are to be counted on as important factors.

Ten per cent. when the building is heated during the daytime only, and the location of the building is not an exposed one.

Thirty per cent. when the building is heated during the daytime only, and the location of the building is exposed.

Fifty per cent. when the building is heated during the winter months intermittently, with long intervals of non-heating.

It may be noted that some engineers are inclined in a few instances to use slightly higher factors than here given. For instance, N. S. Thompson in his "Mechanical Equipment of Federal Buildings" gives constants for concrete that are 50 per cent. greater than the constants for brick herein quoted instead of 20 per cent. greater as given below, while the constants for brick agree very closely.

HEAT LOSS FROM BUILDINGS

B. t. u. Transmitted per Hour per Square Foot of Surface per Degree Difference in Temperature

CONSTANTS FOR BRICK WALLS

Thickness Inches	Plain	Plastered One Side	Air Space and Plastered	Furred and Plastered
4	0.52	0.50		0.28
8½	0.37	0.36	0.25	0.23
13	0.29	0.28	0.21	0.20
17½	0.25	0.24	0.19	0.18
22	0.22	0.21	0 16	0.16
26½	0.19	0.18	0.14	

For **Concrete** walls add 20 per cent. to above values.

Outside walls of frame buildings, lath and plaster inside, outside construction as follows:

Clapboards, 7/16″ thick	0.44
Same with paper lining	0.31
Same with ¾″ sheathing	0.28
Same with paper and ¾″ sheathing	0.23

Inside ordinary stud partitions.

Lath and plaster, one side	0.60
Lath and plaster, both sides	0.34

Sheet iron siding, 1.20.

Corrugated iron siding, 1.50.

FOR VARIOUS WALL CONSTRUCTIONS

Thickness of Board Inches	Pine Board	Double Board Paper Between	Board and Corrugated Iron	Board and Sheet Iron
½	0.77	0.32	0.45	0.50
1	0.51	0.24	0.36	0.40
1½	0.43	0.19	0.30	0.33
2	0.35	0.16	0.26	0.28
2½	0.30	0.14	0.23	0.25

DOUBLE 1″ BOARDS WITH SAWDUST BETWEEN

Sawdust Inches	B. t. u.
2	0.127
4	0.083
6	0.062
8	0.049

FOR FLOOR SURFACES

Single wooden floor, no plaster beneath joists	0.45
Same, lath and plaster beneath joists	0.26
Double wooden floor, no plaster beneath joists	0.31
Same, lath and plaster beneath joists	0.18
Concrete—see concrete walls	

Assume temperature of unheated floor space beneath the floor at one-half the difference in temperature between indoors and outdoors.

FLOORS LAID ON THE GROUND

Cement or tile, no wood above	0.31
Cement or tile, wood floors above	0.10
Dirt, no floor whatever	0.20
Wood, single, laid near ground	0.10

Assume temperature of earth as plus 30° to 50° F.

FOR ROOFING PURPOSES

Sheet iron	1.20
Corrugated iron	1.50
Slate on wooden framing	0.85
Slate on 1″ boards	0.43
2″ boards, paper, tar and gravel	0.26
Patent tar, gravel and paper	0.30
Tiling 1″ thick or less	0.80
6″ hollow tile covered with 2″ concrete, tar and gravel	0.35
2″ concrete with cinder fill	0.80
4″ " " " "	0.60
6″ " " " "	0.54

FOR GLASS SURFACE AND DOORS

Single windows	1.09
Double windows	0.46
Single skylight	1.16
Double skylight	0.48
Pine Doors, 1″	0.41
" " 1½″	0.32
" " 2″	0.27

Heat Loss Through Cold Storage Insulation

Extensive experiments have been made by various investigators who were interested in the subject of heat transfer through the various materials commonly used for insulation in cold storage work. Any apparent discrepancy between the figures quoted by different authors for the same material is probably due to the different conditions under which the tests were conducted.

The following table of coefficients has been compiled by F. E. Mathews, principally from data furnished by the Armstrong Cork Co. This table was published in Power, August 8, 1911. These values are for use under the best conditions, and builders are advised to increase them by 25 to 50 per cent., depending on the physical condition of the insulation.

COLD STORAGE INSULATION

Transmission in B. t. u. per Square Feet per Hour per Degree Difference in Temperature for

Insulating Slabs

1″ "Nonpareil" cork board (pure cork, no foreign binder)	0.271
1″ "Rock" cork (water-proofed rock-wool composition board)	0.308
1″ "Lith" plain (mineral wool flax-fibre composition board)	0.329
1″ "Lith" water-proofed (same as above, water-proofed)	0.350
1″ "impregnated cork board" (gran. cork and asphaltic binder)	0.371
1″ indurated fibre board (indurated wood-pulp board)	0.417

Built-up Insulation (wood and air space)

1″ American spruce	0.700
⅞″ dressed and matched spruce (⅞″ sp. paper ⅞″ sp.) (⅞″ sp. paper ⅞″ sp.)	0.198
(⅞″ sp. paper ⅞″ sp.) (1″ air space) (⅞″ sp. paper ⅞″ sp.)	0.177
6 thicknesses, ⅞″ sp., 3 papers, 2 air spaces arranged as above	0.144
8 thicknesses, ⅞″ sp., 4 papers, 3 air spaces arranged as above	0.113

Built-up Insulation (wood, paper and fill)

(⅞″ sp. paper ⅞″ sp.) (⅞″ sp. paper ⅞″ sp.)	0.198
(⅞″ sp. paper ⅞″ sp.) (4″ min. wool) (⅞″ sp. paper ⅞″ sp.)	0.092
(⅞″ sp. paper ⅞″ sp.) (8″ mill shavings, damp) (⅞″ sp. paper ⅞″ sp.)	0.088
(⅞″ sp. paper ⅞″ sp.) (1″ mill shavings, dry) (⅞″ sp. paper ⅞″ sp.)	0.066
(⅞″ sp. paper ⅞″ sp.) (8″ granulated cork) (⅞″ sp. paper ⅞″ sp.)	0.079
(⅞″ sp. paper ⅞″ sp.) (1″ Nonpareil cork) (⅞″ sp. paper ⅞″ sp.)	0.129
(⅞″ sp. paper) (1″ Nonpareil cork) (paper ⅝″ sp.)	0.136
(⅞″ sp. paper) (2″ Nonpareil cork) (paper ⅝″ sp.)	0.108
(⅞″ sp. paper) (3″ Nonpareil cork) (paper ⅝″ sp.)	0.094
(⅞″ sp. paper) (4″ Nonpareil cork) (paper ⅝ sp.)	0.050
(⅞″ sp.) (1″ pitch) (⅞″ sp.)	0.202
(⅞″ sp.) (2″ pitch) (⅞″ sp.)	0.177

Built-up Insulation (wood, paper, air space and fill)

(⅞″ sp. paper ⅞″ sp.) (1″ air space) (⅞″ sp.) (6″ min. wool) (⅞″ sp. paper ⅞″ sp.)	0.062
(⅞″ sp. paper ⅞″ sp.) (1″ air space) (⅞″ sp.) (6″ gran. cork) (⅞″ sp. paper ⅞″ sp.)	0.061
(⅞″ sp. paper ⅞″ sp.) (1″ air space) (⅞″ sp.) (2″ Nonpareil cork) (⅞″ sp. paper ⅞″ sp.)	0.067

(⅞" sp. paper ⅞" sp.) (1" air space) (2" Nonpareil cork) (paper ⅞" sp.)	0.088
(⅞" sp. paper ⅞" sp.) (1" air space) (3" Nonpareil cork) (paper ⅞" sp.)	0.071
(⅞" sp. paper ⅞" sp.) (1" air space) (4" Nonpareil cork) (paper ⅞" sp.)	0.050
(⅞" sp. paper ⅞" sp.) (1" air space) (5" Nonpareil cork) (paper ⅞" sp.)	0.038

Brick Wall and Sheet Cork

(13" brick wall) (2" Nonpareil cork)	0.115
(13" brick wall) (4" Nonpareil cork)	0.061

NOTE—Sp. designates American Spruce.

The data given in the table following is an extract from a report on Heat Transmission of Building Materials, submitted to the American Society of Heating and Ventilating Engineers, 1913, by Prof. L. A. Harding.

These results were obtained in a specially constructed testing plant, using temperature differences that ordinarily occur, either in heating or refrigerating practice. The testing boxes were made up of the various materials stated, having approximately 100 sq. ft. of surface. Heat was introduced inside the boxes by means of electrical resistance coils, the air surrounding the box being artificially cooled. A strong circulation of air was maintained both inside and outside of the box by fans.

TABLE OF UNIT HEAT TRANSMISSION

B. t. u. Transmission per Sq. Ft. per Hour per Degree Difference in Temperature of Air in Contact with the Two Sides

One 4-in. Hollow Tile	0.625
1 in. Concrete (1-3-5 Mix.)	4.29
⅞ in. Lumber (T and G)	0.83
One Air Space (from 1 in. to 6 in.)	1.66
1 in. Mineral Wool (Dry)	0.666
1 in. Pitch	0.79
1 in. Shavings (Dry)	0.666
1 in. Granulated Cork	0.479
1 in. Corkboard (all Cork)	0.26
1 in. Hair Felt	0.31
1 in. Indurated Fibre Board	0.416
1 in. Compressed Mineral Wool Board	0.33

Heat Loss from Galvanized Iron Pipes

As already explained (page 47) the resistance of any surface to the transmission of heat is the sum of the various resistances to be met in each case, and the transmission or heat loss is the reciprocal of this total resistance. In the case of a galvanized iron duct the conductivity of the material may be neglected, and we have to consider only the resistance to the transfer of heat from the air to the metal on one side and from the metal to the air on the other side. The air in the pipe would have a direction of flow parallel to the surface so that the heat transfer would be as shown in formula (97), page 404, for longitudinal flow. The conditions on the outside of the pipe or duct would be approximately those of any direct radiation placed in the room.

According to the best authorities the coefficient of transmission K for direct radiation from the outside will vary from 1.6 to 1.8 B. t. u. per sq. ft. per hour per degree difference in temperature between the material and the external air. A factor of K = 1.7 B. t. u. is an average value commonly used. Assuming a velocity of 1500 ft. per minute for the air through the pipe, we find from the diagram giving "Rate of Heat Transmission for Longitudinal Flow of Air," on page 406, that for the internal surface of the pipe K = 7.5 B. t. u. The total resistance of the duct will then be

$$\frac{1}{K} = \frac{1}{1.7} + \frac{1}{7.5} = 0.723$$

$$K = 1.38$$

For average conditions as outlined above we may assume for the heat transfer through galvanized iron ducts per sq. ft. per hour per degree difference in temperature between inside and outside

$$K = 1.4 \text{ B. t. u.}$$

$$H = K\,(t_a - t_r) = 1.4\,(t_a - t_r)$$

where H = heat lost per square foot per hour.

t_a = temperature of the air in the pipe.

t_r = temperature of the room.

Heat Loss Due to Infiltration

The heat loss due to leakage and infiltration is often a difficult quantity to determine, inasmuch as it may depend on so many different factors, such as size, height and construction of the building, distribution of doors, windows and ventilators, and the object for which the building is used. For this reason no fixed rule can be given, and the allowance to be made for this loss is necessarily a result of experience and good judgment. It is customary to allow from two changes per hour to one change in two hours as a measure of this loss, depending, as already stated, on the circumstances of the case considered. For the average application one air change per hour is usually a satisfactory allowance.

Thus if the building is very large the ratio of cubic contents to wall surface would be greater than with a smaller building, hence the air change due to leakage would be less frequent.

The existence of large doors frequently opened or of ventilators makes a more rapid air change due to leakage, as does also loosely fitting windows or other faulty construction. Many of the materials used for roofs and siding, such as tile or galvanized iron, are notoriously bad as regards leakage.

The heat required in B. t. u. per hour to warm this air from the outdoor to the room temperature will be

$$H_i = \frac{\text{cubic contents} \times \text{changes per hour} \times \text{temp. rise}}{55.2}$$

Heat Required for Ventilation

The heat required for ventilating is easily computed when the air supplied per hour is actually known. If we consider the specific heat of air at constant pressure to be 0.2415 and the weight of one cu. ft. of air at 70° is 0.0749 lbs., one British thermal unit of heat will raise the temperature of one cu. ft. of air

$$\frac{1}{0.2415 \times 0.0749} = 55.2^{0} \text{ F.}$$

From this we may deduce the formula.

$$H' = \frac{60\, Q\, (t_r - t_1)}{55.2} \quad . \qquad (32)$$

where H' = B. t. u. per hour required for ventilation.

Q = cu. ft. of air per min. required for ventilation.

t_r = room temperature.

t_1 = entering, or outdoor, temperature.

Examples illustrating the use of the above formula will be found in Section VIII, Part IV. For a consideration of the heat given off by the occupants of a room or by various sources of heat, such as lights and machinery, see "Special Ventilation Requirements" on pages 61 and 62.

Air Quantity and Final Temperature Required for Heating

In heating a building by means of the fan system, there are three factors to be considered. These are, the heat loss due to transmission and infiltration; the quantity of air required as a heat carrier; the final temperature and the temperature rise of this air in passing through the heater. Ordinarily the heat loss and one of the other factors are given, with the third to be determined. It may be required to use all return or room air, all outdoor air, or a mixture of the two. The relations between the above factors may be expressed by the following equations:

$$Q = \frac{55.2\ H}{60\ (t_2 - t_r)} \tag{33}$$

and

$$t_2 = \frac{55.2\ H}{60\ Q} + t_r \tag{34}$$

where H = heat loss in B. t. u. per hour due to transmission and infiltration.

Q = cu. ft. of air per minute.

t_2 = temperature of air leaving heater.

t_r = temperature of room.

When using all or part outdoor air there will be sufficient heat required at the heater not only to take care of the heat loss, but also to raise the temperature of the air from entering temperature t_1, to the room temperature, t_r. The total temperature rise will then be $t_2 - t_1$, and

$$H' = \frac{60\ Q\ (t_2 - t_1)}{55.2} \tag{35}$$

where H′ = total heat in B. t. u. per hour required at the heater.

t_1 = temperature of air entering heater—either outdoor or a mixture of room and outdoor air.

t_2 = temperature of air leaving heater.

The amount of steam required will be

$$\frac{H'}{\text{latent heat of steam}} = \text{lbs. per hour.}$$

or approximately lbs. steam per hour $= \frac{H'}{1000}$

SECTION II

VENTILATION

Any room or building used for the habitation or congregation of human beings should be provided with a plentiful supply of fresh air. Strictly speaking, good ventilation is merely a relative term, and the standards as ordinarily accepted are a compromise that will answer the purpose of keeping the air in a building in a fairly fresh condition. The requirements of ventilation are, first, maintaining certain standards of purity of the air within the room or building; second, the removal and prevention of odors; third, the removal of the bodily heat of the occupants together with the heat from such other sources as illumination and power; and fourth, the prevention of excessive rise in humidity which usually accompanies the rise in temperature from bodily heat.

Many of the existing standards of ventilation have been founded on the belief that carbon dioxide was the dangerous element in expired air. The requirements of ventilation as to air purity are more or less arbitrary, and no rational standard has ever been fixed. Later investigations would indicate that carbon dioxide is harmless, and interesting only as indicating how much respiration the air has undergone. In this way it serves as an index of the contamination of the air with organic impurities from the lungs and bodies of the occupants. These organic poisons are little understood, although they undoubtedly constitute the real danger in impure air. The standard of purity which has usually been considered satisfactory is from six to eight parts of carbon dioxide in 10000 parts of air, but it is certain that ten times this amount would not be injurious if provision were made for the removal of organic impurities. In all probability the best index of good ventilation in so far as purity is concerned is freedom from objectionable odors.

It is estimated that the average adult, at rest or doing light work, will breathe approximately 0.25 cu. ft. of air and exhale 0.01 cu. ft. of CO_2 per minute (0.6 cu. ft. per hour), and that only about five per cent. or less of the oxygen is taken out of a breath of air. The air of poorly ventilated rooms will show a slight diminution in the oxygen, accompanied by a corresponding increase in carbon dioxide, organic pollution, and moisture. The poisons in the air due to the presence of too many persons relative to the supply induce a lowering of the vital processes and a loss of muscular strength.

Ordinary outdoor air will contain on an average about four parts of CO_2 in 10000 and fairly good ventilation is ordinarily considered to exist in a room where the air contains not more than from six to eight parts of CO_2 in 10000. That is, if a great amount of CO_2 exists in the air, it is considered as having been breathed too often and unfit for further respiration. The following table gives the amount of air required per hour by the average person, exhaling 0.6 cu. ft. of CO_2 per hour, if it is desired to maintain the corresponding number of parts of CO_2 in the air with outdoor air containing four parts of CO_2 per 10000.

Parts of CO_2 in 10000		Cu. Ft. Air per Hour Per Person
Increase Above Outdoor Air	Total	
1	5	6000
2	6	3000
3	7	2000
4	8	1500
5	9	1200
6	10	1000

It is ordinarily the custom to allow for average conditions 1800 cu. ft. of air per hour per person, and this is the factor commonly used for school ventilation. But there are many cases in which the amount of air allowed is varied to suit the circumstances, a few of which are given in the following table:

AIR ALLOWED PER PERSON CU. FT. PER HOUR

Hospitals (ordinary)	2100 to 2400
Hospitals (epidemic)	4800
Work Shops	1500
Prisons	1800
Theatres	1200 to 1800
Meeting Halls	1200
Schools (per child)	1800
Schools (per adult)	2400

Removal of Bodily Heat

In rooms where the glass and wall exposure is considerable, ventilation for the removal of bodily heat need not be considered, except where the building is artificially cooled. In crowded audience halls, however, and even in school-rooms it is the determining factor. Each adult occupant gives off an average of 400 B. t. u. per hour, of which approximately 150 B. t. u. may be assumed to be latent heat of evaporation, while not more than 250 B. t. u. will be sensible heat given off by the breath and by convection to the surrounding air. On this basis if each occupant is supplied with 30 cu. ft. of air per minute or 1800 cu. ft. per hour there will be a rise of approximately eight degrees above the temperature at which the air is introduced into the room, so that in order to maintain we will say 70 degrees in the room, the air would have to be reduced to 62 degrees. There is evidently a limit to the difference of temperature allowable between incoming air and room temperature, which depends largely on the size and arrangement of inlet openings as effecting the production of cold drafts. The practical limit is found in standard methods of ventilation to be between 5 and 10 degrees. Therefore, the limiting quantity of air required for the removal of bodily heat must be taken approximately between 25 and 50 cu. ft. per minute per adult occupant. This, as may be noted, also gives a very satisfactory standard of purity.

While 1800 cu. ft. of air per hour or 30 cu. ft. per minute (expressed as 30 A. P. M.), when used as a standard for overhead ventilation, is in the average case amply sufficient to take care of the heat and moisture from the body, when the air is supplied through many small openings distributed about the room a smaller quantity of air may often be supplied. Several different systems of this character have been used, such as introducing the air under the seats in a theatre, or through a small opening at each desk in a school. By this means a more uniform distribution of the air is obtained than is possible with the over-head system, with greater assurance that each occupant of the room will receive the desired amount of fresh air.

Carbon Dioxide Determination

Various methods for making analyses of the air to ascertain the CO_2 content have been used, but it is generally considered that the more simple methods are little better than approximations. The more dependable methods require carefully prepared apparatus, and an operator who has had considerable experience in this or similar chemical work. One of the methods quite generally used for this determination is called the Pettenkofer method.

The Pettenkofer method of analyses for carbon dioxide is based on the fact that barium hydroxide will absorb the CO_2 from the atmosphere. A measured bottle or flask is used to collect the sample of air, some form of bellows or air pump being used to force the room air into the bottle. This operation is continued for several seconds, or until the air in the bottle has been changed quite a number of times (six to ten).

After the sample is collected, a definite quantity of standard barium hydroxide is inserted into the bottle to absorb the CO_2 from the sample of air contained. At the same time a few drops of penolphthalein is added to the barium hydroxide in the bottle, giving the mixture a reddish color. The sample should then be allowed to stand for at least an hour, being frequently shaken, although the final operation may be left till the next day if desired. The excess of barium hydroxide is then titrated with standard oxalic acid, by dropping the acid into the reddened solution until the color disappears. This oxalic acid should be dropped into the sample bottle from a graduated burette, so that the exact amount of acid required to titrate the barium hydroxide not absorbed by the carbon dioxide may be measured. Previous determinations having been made to find the amount of oxalic acid required to titrate a quantity of barium hydroxide equal to that put into the bottle, the difference in the acid used before and after taking the sample is a measure of the barium hydroxide uniting with the CO_2. One c. c. of the oxalic acid is equivalent to 1/10 c. c. of carbon dioxide.

Special Ventilation Requirements

There are other factors that may have to be considered in making a determination of the air quantity to be supplied for ventilating purposes. Some of these special cases are where provision is to be made to care for the heat given off by furnaces or machinery; the effect of gas jets or other lighting apparatus; or to remove the heat radiated from the bodies of the occupants of the building.

The allowance to be made for many sources of heat, such as furnaces, is often a matter of experience and good judgment, but in case of machinery using a known amount of power the heat expended may be determined on the basis of 2545 B. t. u. per hour or 42.416 B. t. u. per minute per horsepower.

The following data concerning the heat given off to the air by various electric lights is based on the standard of 2545 B. t. u. per hour per H. P.; and 1 H. P. = 746 watts, giving 3.41 B. t. u. per watt as the heat radiated. This gives the B. t. u. per hour for the following lamps:

25 watt lamps	85
50 watt lamps	170
400 watt lamps	1360
600 watt enclosed arc	2040

Prof. Kinealy quotes the following values for the heat radiated in B. t. u. per candle power per hour.

Gas, ordinary split burner	300
Gas, Argand burner	200
Gas, Auer burner	31
Gas, Welsbach burner, 16 c. p.	60
Petroleum	160
Electric, incandescent	14
Electric, arc	4.3

The following data gives the values commonly quoted as the bodily heat given off in B. t. u. per hour per person.

Child 6 years old	240
Adult at rest	380
Man 30 years old in an atmosphere with a temperature of 31° F.	600
Adult in old age	360

The amount of heat in B. t. u. usually assumed as given off per person per hour in an atmosphere at 70° F. is 400 for adults and 200 for children. These are the figures generally used when the heating effect of the occupants of assembly halls, auditoriums, or factories is taken into account.

The proper allowance for the above sources of heat is of especial importance in the design of apparatus used for cooling a building in the summer-time. The heating effect of the direct sun on walls and glass surface has also to be considered, the ordinary factors in B. t. u. per hour per square foot of surface being:

Sun effect—13-inch brick wall, 6.0 B. t. u. per sq. ft. per hr.
Sun effect—glass, 150.0 B. t. u. per sq. ft. per hr.

The Fan System for Heating and Ventilating

While for heating purposes the fan heating system may or may not be used, depending on circumstances and the requirements to be met, yet for purposes of ventilation the fan system is practically without competition. The fan system may be

Three-Quarter Housing Fan, Left-Hand Top Horizontal Discharge, Blowing Air Through and Underneath Heater into Brick Plenum Chamber

used to supply both heat and fresh air for ventilation or it may be used in conjunction with some form of direct radiation which is to care for the heat losses. When used for ventilating purposes the fan will be required to supply whatever amount of air is specified to meet the ventilation requirements.

Arrangement of Apparatus

Fan system apparatus, consisting of a fan and some form of indirect heating coil, may be arranged either to exhaust the air through or to blow through the heater, commonly called the **exhaust-through** or **draw-through** and the **blow-through** apparatus. Each arrangement possesses its own peculiar advantages but the selection depends largely upon the individual requirements of the installation. An exhaust fan is slightly less efficient than a blower, but in a draw-through system the air blows directly from the fan into the piping system with but little, if any, change in velocity. On the other hand when using a blow-through apparatus the velocity of the air leaving the fan must be reduced through the heater and then raised again through the piping system, both changes entailing a loss in pressure.

The exhaust-through apparatus is usually employed in factory buildings on account of its compactness as well as the advantage gained by connecting directly to the piping system. In this case the temperature of the air delivered will be the same to all parts of the building. The blow-through apparatus is used in public buildings or wherever different temperatures and independent temperature regulation are required for different rooms of the building. The use of the by-pass around the heating coils permits the mixture of hot and cold air in any desired proportions, by the use of a mixing damper at the point where the two ducts from the heater and from the by-pass join to form one duct leading to the room. In the case of public buildings the fan frequently blows the warm air into a space called a plenum chamber, from which the air ducts radiate to the various rooms of the building. For this reason this system is sometimes called the **plenum system** of heating and ventilating.

Upward and Downward Systems of Ventilation

For audience halls the problems of air distribution and avoidance of drafts are greatly increased owing to the usual large dimensions of such buildings, and the density to which they are peopled. Two plans of ventilation are in vogue, usually distinguished as the upward and the downward systems of ventilation. In the upward method the air is admitted through perforations in the floor underneath the seats and is allowed to escape through ventilators in the roof. In the downward system the air is admitted through registers in the walls at a height of several feet above the floor, and removed through vent registers in the walls at the floor line in the same manner as in school buildings. In large auditoriums the upward method is doubtless preferable when the architectural design makes it permissible. A perfect distribution of the air can be secured, and the air flow is upward in accordance with natural currents induced by the heat of the body and the breath, the products of respiration are immediately carried away, and the incoming air is uncontaminated. This method of ventilation is exceedingly efficient, as a high standard of purity can be maintained at the breathing line with a comparatively small air supply.

Upward ventilation to be successful requires a very careful arrangement of the supply openings on account of the greater liability of drafts. The velocities are necessarily low, and the registers are so small that a very large number is needed to convey the necessary air. The plenum chamber for the supply is sometimes out of the question, and on this account the downward system, which is in almost universal use in schools, is extended to churches, theatres and halls with high ceilings. With a proper arrangement of fresh air and vent registers and ample air supply excellent results are obtained. To insure such results exhaust systems are frequently relied upon, the vent registers being connected with suction fans which maintain a steady draft.

Schoolhouse Ventilation

Modern school buildings offer most exacting requirements in heating and ventilation. On account of the large number of pupils seated in one room, a very rapid air change is required, and this must be accomplished without drafts. The temperature must be uniform everywhere, and ventilation must be adequate. Even elaborate systems can not secure entirely perfect distribution of air, and the only practical and successful method of insuring ample ventilation in all parts of the room is to supply air considerably in excess of the theoretical requirements. The necessity of this added capacity, or factor of safety as it may be termed, is often overlooked in writing specifications for school buildings. Thirty cubic feet of air per pupil which is usually specified will allow from six to seven parts CO_2 in 10000. Individually this is ample, but collectively insufficient, since to insure that this per cent. of CO_2 is nowhere exceeded, it would probably be necessary to supply an average of nearly 40 cu. ft. per pupil.

Ventilation of Industrial Buildings

Where an industrial building is heated by means of a fan system apparatus and no special air requirement exists, except in certain cases, it is not customary to provide for ventilation aside from taking the air for heating purposes from the outdoors. Certain industrial processes require ventilation either for cooling or for the removal of obnoxious gases and fumes or of steam. For such cases it is advisable to use an exhaust system where practicable. The air should be exhausted if possible at the point where the heat or objectionable gases escape.

It is customary to suspend a hood directly above the source of heat or gases, this hood being connected by a duct or pipe to the inlet of an exhaust fan or to a vent stack. These hoods are usually so proportioned as to obtain a velocity of from 75 to 250 feet per minute over their area, according to the location of the hood. Full directions for the design of such a system, with data on the size of hoods and piping to be used, will be found under "Exhaust Systems" on page 93, and on "Proportioning Piping for Exhaust Systems" on page 129. Data on the design of piping systems for various purposes will also be found under "Air Ducts," Part III.

A few of the more common air changes provided for ordinary conditions are:

Laundry—1 to 3 minute air change depending on the size of the room and the concentration of the heat.

Hotel kitchen—4 minute air supply and 3 minute exhaust. This tends to place the room under a slight vacuum, so that any leakage at the doors is into rather than outward from the kitchen.

Engine and boiler room—3 minute supply and 4 minute exhaust.

Foundry—15 minute air change when air is taken from outside.

Roundhouse—10 to 12 minute supply in order to keep the air free from steam and smoke.

Cooling occupied rooms in summer without refrigeration usually calls for from 4 to 6 minute air supply.

SECTION III

Air Washing, Cooling, Humidifying,* Drying

AIR WASHING

On account of dust and soot introduced by a ventilating system, some form of air washer or air filter is essential where cleanliness is of importance. The spray type has superseded cloth screens and other methods of wet cleaning on account of its greater efficiency and is now standard practice for ventilating equipment.

The advantages to be derived both in industrial establishments and in public buildings by maintaining any desired degree of moisture in the air, as well as freeing it from impurities, have become very widely recognized. This process is generally termed **air conditioning.** This conditioning can be most successfully accomplished by passing the air through a spray type of air washer or humidifier where additional moisture is desired, or by using a spray type dehumidifier when the moisture content of the air is already too great and requires reduction.

Humidity in Heated Buildings

In schools and other public buildings the humidity of the air is of more consequence than is usually supposed. The amount of moisture which air can hold at saturation per unit volume increases rapidly with the temperature as shown by the psychrometric chart on page 35. Air normally has a humidity varying from 40 to 50 per cent. of saturation, while if much above or below these limits it becomes uncomfortable if not actually injurious to the health. Hence air at 70° should contain from 3.5 to 5.5 grains per cubic foot, while at 0° it contains only about 0.3 grains and at 32° about 1.25 grains, so that in the usual systems of heating, with 32° outside, the humidity of the air when heated to 70° would be only 15.5 per cent. The effect of this ex-

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*NOTE.—For a general discussion of the subject of Humidity see page 28, Part I. For details of the performance and dimensions of Carrier Air Conditioning Apparatus see Section VI, Part IV.

treme dryness is undoubtedly very harmful to the mucous membrane in the nose, throat and the lungs, and may be considered a contributing source of many throat and pulmonary diseases.

The proper humidity to maintain in public buildings is from 35 to 50 per cent. The humidity to be recommended in good practice is 40 per cent., with a room temperature of 68° F. This corresponds to about three grains of moisture per cubic foot of air and a dew-point of 42°. Even this will cause slight condensation on the windows in extremely cold weather and a lower humidity should be maintained in very cold weather if condensation on the windows is objectionable.

Humidity in Manufacturing Establishments

In the case of industrial installations the amount of moisture required in the air will vary widely according to the nature of the process, some requiring high and others low relative humidity. In textile mills the necessity of humidifying and cooling the air has long been understood. Just as in many instances the fan system has superseded other methods of drying materials, it is to be expected that air conditioning apparatus with automatic control of humidity will find new applications in which economy of operation will justify the expense.

COOLING

One of the special developments in connection with the fan system of ventilating is the cooling of a building so that the indoor temperature in summer will be lower than that outdoors. A limited amount of cooling may be obtained by passing the air through an air washer in which cold water is used, and for many purposes this will be found sufficient. In case a considerable temperature difference is desired, or when a great amount of heat is to be taken care of, as from machinery and other apparatus in a factory, a special form of washer known as a dehumidifier is used. This is generally operated in two stages or sets of sprays, one using cold well water and the second using refrigerated water. With such an apparatus any desired dew-point or per cent. of relative humidity may be maintained in the room to be conditioned, and the air may be delivered as low as 39° or 40°.

It is not generally considered desirable to have too great a difference between the room and outdoor temperatures, on account of the chilling effect to persons coming in from the outdoor air. A difference of from 10° to 15° will generally be found the most desirable. The incoming air must be cooled to a temperature enough lower than the room to take care of any heat generated in the room, as well as the heat transmitted through the walls from the warmer outdoor air. In case the relative humidity of this air is then too great, the moisture content may be reduced by lowering the temperature still further, so condensing a portion of the moisture from the air. The amount of moisture contained at different saturation temperatures may be found from the psychrometric tables on pages 38 to 45.

Relation of Cooling Effect to Percentage of Relative Humidity

In the moist air system of humidifying it is evidently essential, as shown in the table on page 71, that the difference between the dew-point temperature of the incoming air and the room temperature shall not exceed a predetermined value, depending upon the percentage of humidity to be maintained. The minimum temperature at which air can be introduced is evidently the dew-point or saturation temperature at the apparatus. This permissible temperature rise limits the possible cooling effect to be obtained from each cubic foot of air as shown in the table of cooling capacities. This relationship is of primary importance in the design of the humidifying system and the disregard of it has been the chief cause of failure or of unsatisfactory operation.

COOLING CAPACITY OF CARRIER HUMIDIFYING SYSTEM

Per Cent. Humidity in Room	Difference between Dew-point and Room Temperature	Cu. Ft. of Air at 70° Fahr. Required per B. t. u. Cooling Effect
50	20.3	2.71
55	17.7	3.11
60	15.2	3.63
65	12.8	4.31
70	10.8	5.10
75	8.8	6.27
80	6.8	8.11

In the majority of industrial applications the problem during warm weather, and in some instances throughout the entire year, is as much a question of cooling as of humidifying. Indeed, in the moist air system, as has just been shown, one is dependent on the other. In every industrial air conditioning plant there are four sources of heat which must be taken into account in the design of the system:

(a) Radiation From Outside Owing To The Maintenance Of A Lower Temperature Inside. At ordinary humidities this is negligible, but at high humidities and in dehumidifying plants it is an important factor, owing to the increased temperature difference. This may be calculated from the usual constants of radiation.

(b) Heating Effect Of Direct Sunlight. This is especially noticeable from window shades and exposed windows and skylights where the entire heat energy of the sunlight is admitted to the room, and from the roof which constitutes the greater amount of sunlight exposure and which in ordinary construction transmits heat much more readily than the walls. Precautions should be taken where high humidities are desired to shade exposed windows and to insulate the roof thoroughly. Ventilators in the roof are of great advantage in removing the hot layer of air next it and those of ample capacity should always be provided.

(c) Radiation Of Heat From The Bodies Of The Operatives. This amounts to about 400 to 500 B. t. u. per hour per operative, about one-half of which is sensible heat, the other half being transformed into latent heat through evaporation.

(d) Heat Developed By Power Consumed In Driving Machinery And In Manufacturing Processes In General. According to the laws of conservation of energy, all power used in manufacturing is ultimately converted entirely into its heat equivalent. Each horsepower of energy, therefore, creates 42½ B. t. u. of heat per minute, which must be cared for by ventilation. In high-powered mills this is the chief source of heating and is frequently sufficient to overheat the building even in zero weather, thus requiring cooling by ventilation the year round.

It must be remembered that in cooling moist air the latent heat removed in condensing the moisture is usually of more importance than the reduction in the sensible heat of the air itself. The total heat removed may be determined from the total heat curve of the diagrams on pages 36 and 37. It should also be noted that the total heat of the air is dependent on the wet-bulb temperature only, and the wet-bulb temperature should always be used in such calculations.

DEW-POINT TEMPERATURES AND TEMPERATURE DIFFERENCES REQUIRED IN CARRIER SYSTEM OF HUMIDIFYING FOR VARIOUS PERCENTAGES OF HUMIDITY AND ROOM TEMPERATURES

Room Temperature Deg.	Percentage Relative Humidity																	
	75		70		65		60		55		50		45		40		35	
	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.	Dew-Point Temp.	Difference between Dew-Point and Room Temp.
65	56.75	8.25	54.75	10.25	52.8	12.2	50.7	14.3	48.3	16.7	45.8	19.2	43.0	22.0	40.0	25.0	36.75	28.25
70	61.6	8.4	59.6	10.4	57.5	12.5	55.3	14.7	53.0	17.0	50.5	19.5	47.5	22.5	44.5	25.5	41.0	29.0
75	66.3	8.7	64.3	10.75	62.25	12.75	60.0	15.0	57.75	17.25	55.25	19.75	52.75	22.75	49.0	26.0	45.5	29.5
80	71.2	8.8	69.25	10.75	67.2	12.8	64.8	15.2	62.3	17.7	59.75	20.25	56.75	23.25	53.5	26.5	49.75	30.25
85	76.2	8.8	74.1	10.9	71.75	13.25	69.4	15.6	66.9	18.1	64.25	20.75	61.25	23.75	58.0	27.0	54.2	30.8
90	80.9	9.1	78.8	11.2	76.7	13.3	74.2	15.8	71.6	18.4	68.75	21.25	65.75	24.25	62.5	27.5	59.0	31.0
95	85.75	9.25	83.6	11.4	81.3	13.7	78.8	16.2	76.25	18.75	73.35	21.65	70.3	24.7	67.0	28.0	63.2	31.8

Relation of Room Temperature to Outside Wet-Bulb Temperature

During cool weather the dew-point or saturation temperature at the apparatus is secured and controlled artificially at whatever point required. During warm weather however, it is impossible during the greater part of the time to obtain as low a dew-point as desired without refrigeration, which in the majority of cases of humidifying is impracticable. The lowest saturation temperature that can be obtained with an efficient spray system is the same as the **outside wet-bulb temperature,** as has been shown; therefore the dew-point in the room will always be the same as the outside wet-bulb temperature. Since the difference between the dew-point and the room temperature is dependent upon the percentage of relative humidity maintained, the minimum room temperature and the percentage of humidity required in the enclosure will be as shown in table on page 71. It will be noted that the lower the humidity carried, the lower the dew-point must be for any given room temperature.

Dew-Point Method of Humidity Control

Any one of the three spray types of air conditioners previously described are admirably adapted for humidity control by what is known as the dew-point method. This system is applicable only where the absolute moisture content of the air in the room is unaffected to any great extent by extraneous sources of moisture supply or by moisture absorption. It depends upon supplying the enclosure with conditioned air having a definite dew-point and maintaining a predetermined relationship between the dew-point temperature and the room temperature. The dew-point of the air supply is determined by saturating the air and removing all free moisture at the apparatus at a definite temperature. This dew-point will evidently remain constant regardless of subsequent variations in air temperature. It may be shown that the percentage of relative humidity in an enclosure is dependent upon the difference between the dew-point temperature and the room temperature, and that it is substantially constant for any variation in room temperature so long as the difference between the dew-point and room temperature is maintained constant. (See table page 71.)

HEAT REQUIRED TO CONDITION 1000 CU. FT. OF AIR (MEASURED AT 70 DEG. FAHR.) FROM VARIOUS ENTERING WET-BULB TEMPERATURES TO VARIOUS DEW-POINT TEMPERATURES

Wet-Bulb Temperature of Entering Air	At 70 Deg. Fahr., 30 Per Cent. Humidity, Dew-Point 37.25 Deg. Fahr.			At 70 Deg. Fahr., 40 Per Cent. Humidity, Dew-Point 44.5 Deg. Fahr.			At 70 Deg. Fahr., 50 Per Cent. Humidity, Dew-Point 50.5 Deg. Fahr.		
	Sensible Heat	Latent Heat	Total Heat	Sensible Heat	Latent Heat	Total Heat	Sensible Heat	Latent Heat	Total Heat
-10	856	338	1194	981	471	1452	1086	567	1653
0	673	311	984	802	444	1246	907	540	1447
10	480	270	750	622	403	1025	730	498	1228
20	307	203	510	443	336	779	550	433	983
30	200	100	300	263	233	496	370	330	700
40				82	96	178	190	194	384

Wet-Bulb Temperature of Entering Air	At 70 Deg. Fahr., 60 Per Cent. Humidity, Dew-Point 55.3 Deg. Fahr.			At 70 Deg. Fahr., 70 Per Cent. Humidity, Dew-Point 59.6 Deg. Fahr.			At 70 Deg. Fahr., 80 Per Cent. Humidity, Dew-Point 63.5 Deg. Fahr.		
	Sensible Heat	Latent Heat	Total Heat	Sensible Heat	Latent Heat	Total Heat	Sensible Heat	Latent Heat	Total Heat
-10	1161	699	1860	1243	801	2044	1310	935	2245
0	991	672	1663	1066	774	1840	1131	908	2039
10	814	631	1445	888	733	1621	955	867	1822
20	635	565	1200	710	667	1377	779	802	1581
30	457	463	920	532	565	1097	600	700	1300
40	276	327	603	353	430	783	423	564	987
50	83	137	220	154	240	394	244	375	619
60							63	118	181

It is evident that this system is particularly adapted to thermostatic control of (a) the dew-point (saturation temperature at the apparatus) and the room temperature independently; (b) of the dew-point with reference to a variable room temperature; or (c) of the room temperature with reference to a variable dew-point temperature. System (a) is generally applied to air washers and humidifiers under winter conditions, where the outside temperature is considerably lower than the room temperature and to dehumidifiers where it is possible to maintain a definite dew-point temperature throughout the entire year.

However, during summer conditions the saturation point at the apparatus will frequently and unavoidably be higher than the required minimum dew-point. Under such variable temperature conditions it is necessary to control temperature with reference to the dew-point according to system (c) and a humidifier is employed to give the air complete saturation under these conditions. A differential thermostat effects this control.

Automatic Humidity Control

In many industrial installations where humidifying or dehumidifying systems are used, some means of positively and accurately maintaining the proper temperatures and humidities is essential. While much can be accomplished by hand regulation, this would require the constant attention of a highly skilled operator which in most instances is impracticable. In many processes of manufacturing, as, for example, the weaving of silk and in the conditioning of tobacco for the manufacture of cigars, a uniformity of humidity conditions is quite as essential as the quantity of moisture, as any variation in humidity, either above or below a standard, reduces the output and causes lack of uniformity in the product. In many cases a sensitive automatic humidity control is as important as some means of humidifying. There are three distinct methods by which such automatic control can be secured:

(a) By two separate thermostats, one of which is placed at the humidifier to control the temperature of the dew-point by an automatically operating valve or damper, governing a means of varying the temperature of the spray water, of the entering air, or of both in conjunction. The other thermostat, placed in a room where the humidity is controlled, maintains a constant room temperature, either by controlling the temperature of the air entering the room, or by controlling some source of heat within the room. With these two temperatures maintained constant, the percentage of humidity in the room will remain constant, and will depend upon the difference between the dew-point temperature maintained at the humidifier and the temperature maintained in the room, as shown by the table on page 71.

(b) By a differential thermostat. This type of dew-point control is required wherever it is impracticable to maintain either a constant dew-point or a constant room temperature. In this method there are two elements, one of which is exposed to the dew-point temperature, while the other is exposed to the room temperature. They are so connected that they act conjointly upon a single thermostatic valve connected with operating motors arranged to control the dew-point temperature in relation to the variable room temperature, or to control the room temperature with respect to the variable dew-point temperature.

(c) By means of some form of differential hygrostat. This controls the wet-bulb temperature with respect to the dry-bulb temperature, so as to maintain a constant relative humidity without regard to the dew-point or variation in room temperature.

DRYING

The drying of materials of various kinds may be accomplished either by means of direct radiation from some source of heat, or by means of air currents, depending on the character of the installation or the requirements to be met. Drying by means of air currents may be done either by means of natural circulation, or by the use of some form of fan—either of the disk wheel or steel plate type. This air is usually warmed, either by some form of heating coil or by means of waste heat, the temperature ranging say from 70° to 200° depending entirely on the nature of the substance to be dried. In some cases this temperature is varied at different periods of the operation. The time required may be anywhere from a few minutes to several days. In many cases a combination of the above systems are used—that is, both direct radiation and air circulation.

Dryers are ordinarily built in either the room type or the continuous (or progressive) type. In a room dryer the material to be dried is placed in the room and left for a certain period until drying is accomplished. In the progressive type wet material enters at one end, and is taken from the other in a dried condition. The entering end of the dryer is termed the green or wet end and the leaving end the dry end. In a continuous dryer it is customary to introduce warm air at the dry end and exhaust it at the wet end, this air being either discharged to the atmosphere or returned to the fan to be recirculated. The apparatus is usually so arranged that any desired proportion of this return air may be recirculated, depending on the varying atmospheric conditions. The drying apparatus itself may take any one of several forms, depending on the material handled, which may be spread on trays, placed in a revolving cylinder, on a traveling conveyor, or in a room or kiln. A drying room or compartment is frequently referred to as a drying tunnel. Except in the case of cylinder driers or continuous conveyors it is customary, whenever practical, to load the material on trucks or small cars in order to facilitate the filling and emptying of the drying tunnel or kiln. The dryer should be so designed that a clear area for the passage of air is provided equal to ½ to ⅔ the cross sectional area of the dryer.

The amount of moisture carried in the air is of as great importance as is proper temperature in many classes of drying work which require either a high or a low moisture content, or often a varying amount of moisture at different periods of the drying for different substances. Any desired amount of moisture may be obtained by passing the air through a humidifier or a dehumidifier, depending on the conditions desired, or the humidity of the air may frequently be controlled by recirculating varying amounts of the moist air leaving the dryer.

The temperature drop through the dryer or tunnel must be sufficient to care for the following heat losses; (a) Radiation from the walls, (b) Heat required to raise the temperature of the material being dried, including the contained moisture, as well as the trucks or other apparatus from the room to the dryer temperature, (c) Heat required to evaporate the moisture removed by the air, which is the principal requirement. Sufficient quantity of air must be supplied to act as a heat carrier without having the temperature leaving the dryer drop too low. The air quantity must also be sufficient to remove the desired weight of moisture without bringing the air to saturation at the green end of the dryer. The relative humidity of the air leaving the dryer is ordinarily kept below 75 per cent.

The quantity of air to be supplied by the fan, or frequency of the air change in the drying chamber, depends upon the rate at which moisture is given up by material. This will vary with every class of installation, in some cases as high as ¼ minute air change being used. The theoretical amount of moisture which the air will remove is directly proportional to the difference between the wet and dry-bulb temperature of the entering air, while the actual amount absorbed by a given quantity of air is measured by the drop in dry-bulb temperature between the air entering and leaving the dryer, less a slight correction for radiation. For the same reason the higher the temperature of the entering air (the initial moisture content remaining the same) the greater will be the amount of moisture removed per given quantity of air and the greater will be the economy of the dryer.

The temperature of the air will drop approximately 8½° for each grain of moisture absorbed per cubic foot of air measured at 70°, or 0.71 of a degree for each grain of moisture absorbed per pound of air. Approximate calculations may be based on air volume, but for exact determinations the weight of air handled should be used, on account of it being a fixed quantity at all temperatures. Knowing the rate of drying desired and the amount of moisture to be removed, it is a simple matter to determine the quantity of air required.

The following table of drying conditions is given by H. C. Russell* and will show some of the variations required in this work:

CONDITIONS FOR DRYING DIFFERENT MATERIALS

Material	Temp. (Deg. F.)	Drying Period
Sole leather hides	90	4 to 6 days
Thin leather hides	90	2 to 3 days
Bone glue	70 to 90	4 days
Skin glue	70 to 90	2 days
Starch	180 to 200	12 hours
Apples	140 to 180	6 hours
Leaf tobacco	85	
Stem tobacco	200	
Soap	100	2 days
Wool	105	
Rags	180	
Pottery	120	

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*Drying Apparatus by H. C. Russell, Am. Soc. H. & V. Engrs., 1912.

The table on page 79 giving the "Moisture Removing Capacity of Air in Fan System Dryers" will be found especially convenient for use in drying calculations, as it will serve as an indication of the results to be obtained under any given conditions. Two sets of values are given, for air entering the heater either at 50 per cent. or 100 per cent. saturated. It will be noted that the results given are based on the assumption that the air leaves the dryer saturated, but as already explained, in practice the air absorbs only about 60 to 70 per cent. of this theoretical amount. Under these conditions about two-thirds as much moisture will be removed per cubic foot or pound of air as is given in the table, and the air quantity would be increased 50 per cent.

The specific heat of various substances will be found below.

SPECIFIC HEAT OF VARIOUS SUBSTANCES*

Solids		Solids	
Wrought iron	0.1138	Brickwork	about 0.200
Cast iron	0.1298	Masonry	about 0.200
Steel (soft)	0.1165	Marble	0.210
Steel (hard)	0.1175	Coal	0.200 to 0.241
Copper	0.0951	River sand	0.195
Brass	0.0939	Pine (turpentine)	0.467
Lead	0.0314	Oak	0.570
Tin	0.0562	Fir	0.650
Alumina	0.1970	Glass	0.194
Zinc	0.0956	Ice	0.504

Liquids		Liquids	
Water	1.000	Benzine	0.393
Alcohol (absolute)	0.700	Turpentine (density 0.872)	0.472
Alcohol (density 0.793)	0.622	Ether	0.503

Gases	Constant Pressure	Constant Volume
Oxygen	0.21751	0.15507
Hydrogen	3.40900	2.41226
Nitrogen	0.24380	0.17273
Carbonic acid	0.21700	0.17100
Marsh gas	0.5929	0.4683
Blast—furnace gas	0.2277	

*Kent's Mechanical Engineer's pocket book.

MOISTURE REMOVING CAPACITY OF AIR IN FAN SYSTEM DRYERS

Initial Temperature Entering Dryer Deg. F.	Air Entering Heater at 70° F. and 50% Rel. Hum.				
	Temp. Deg. F. at Saturation Leaving Dryer	Weight of Moisture Absorbed at Saturation		Cu. Ft. Air at Saturation Required to Evaporate 1 Lb. of Water	Lbs. of Steam at 212° F. Required per Lb. of Water Evaporated
		Grains per Lb. of Air	Grains per Cu. Ft. at 70°		
80	62.1	28.6	2.12	3300	0.455
90	65.5	39.7	2.94	2380	0.773
100	68.7	51.2	3.80	1845	0.944
110	71.7	62.5	4.63	1515	1.050
120	74.5	74.5	5.52	1270	1.118
130	77.0	87.0	6.45	1085	1.152
140	79.6	99.5	7.38	950	1.187
150	81.8	112.0	8.30	845	1.210
160	84.3	125.0	9.26	755	1.230
170	86.4	138.0	10.20	685	1.240
180	88.4	151.0	11.20	625	1.255
190	90.3	164.5	12.20	575	1.260
200	92.2	178.5	13.20	530	1.260
	Air Entering Heater at 70° F. and Saturated				
80	72.9	11.6	0.85	8240	1.490
90	75.6	23.9	1.75	4050	1.480
100	78.3	36.3	2.65	2640	1.470
110	80.7	48.8	3.56	1965	1.465
120	83.0	61.8	4.52	1525	1.455
130	85.2	74.8	5.46	1280	1.440
140	87.3	87.8	6.41	1090	1.435
150	89.3	101.8	7.44	934	1.418
160	91.2	116.3	8.50	827	1.395
170	93.0	130.8	9.55	732	1.380
180	94.8	145.3	10.62	662	1.365
190	96.5	159.8	11.68	600	1.355
200	98.1	174.3	12.75	562	1.350

Example. The quantity of moisture which a given amount of air may be expected to remove from the contents of a drying chamber may be determined from the psychrometric charts on pages 35 to 37. Let it be assumed that the air to be used as a drying medium contains 50 grains of moisture per pound under the average conditions at which it enters the heater. Here the air is warmed and delivered to the dryer at say 150° Fahr. The moisture content of this air will still be the same as first considered, that is, 50 grains per pound of air.

The amount of moisture which this air will remove may be determined from the high psychrometric chart on page 37. The first step is to find the intersection of the horizontal line through 50 grains per pound with the vertical line through 150° dry-bulb temperature, and by following the diagonal through this point to the saturation curve, we have a wet-bulb temperature of 81°, which is the temperature the air would assume if brought to saturation. Following the horizontal from this point to the left edge of the chart, it will be seen that at saturation this air would be capable of containing 165 grains per pound, or an increase of 115 grains. In practice it is impossible to bring the air to saturation, the limit generally being from 65 to 75 per cent. of the theoretical increase. Assuming that the air under consideration will absorb 70 per cent. of the 115 grains indicated above, gives us 80 grains of moisture absorbed per pound of air.

Inasmuch as a draw-through outfit will generally be used for this class of installation, the fan will handle the air at a temperature enough above 150° to care for the radiation loss from the connections. The quantity of air handled will then be based on 50 grains per pound and a temperature of at least 150°, or, as found from the psychrometric chart, approximately 13.7 cu. ft. per pound. Then $80 \div 13.7$ gives 5.85 grains absorbed per cubic foot of air. On the basis that each grain absorbed will reduce the temperature of the air 8.5°, we will have a drop in temperature through the dryer of $8.5 \times 5.85 = 50°$. There will be an additional drop in temperature due to the radiation loss from the walls of the dryer, as well as due to the heat required to raise the contents to the temperature of the dryer.

SECTION IV

MECHANICAL DRAFT

There are two methods in common use for removing smoke and gases from a boiler, by means of a chimney or natural draft, and by means of a steam jet or a fan, commonly called **mechanical draft.**

Mechanical draft possesses many advantages over natural draft, in that it is independent of atmospheric conditions, and absolute command of the draft enables the boilers to be operated at capacities greatly in excess of that possible when depending on natural draft. Indeed it is directly responsible for the high rates of combustion and the increased efficiency obtained with modern boiler plants. Heat in the escaping gases may be largely used in economizers, since it is not required to create draft, resulting in a considerable saving. It is also possible to burn a cheaper grade of fuel when using the mechanical draft systems.

Mechanical draft produced by a fan is commonly classified under two heads, **forced** draft and **induced** draft. Each of these systems has its advantages and each has special features which recommend it for different cases.

Forced Draft

In the case of forced draft, air is forced by the fan through the fire, maintaining a pressure in the ash pit and furnace greater than that of the atmosphere. Forced draft is applied in two ways: The plenum system used in steamships, where forced draft creates a pressure in the entire stoke-hold, and the **direct system** where the fan discharges directly into the ash pit beneath the grates. Forced draft is always used with underfeed stokers on account of the restricted area of tuyere openings.

With forced draft the blower should be run at a pressure sufficient to overcome the resistance of the grate; the pressure losses in the tubes and breeching all being taken care of by the stack, with an indraft above the fire of from 0.05 to 0.10 of an inch. Hence forced draft requires a higher stack than would an induced draft system, since its action practically ceases at the surface of the fire. If a greater pressure should be carried, the result would be a pressure in the fire-box greater than that existing in the room, so there would be an out-rush of flame and smoke when the fire-door was opened.

Induced Draft

In the induced draft system the fan is placed at the base of the stack and handles the smoke and gases. By this means a partial vacuum is maintained within the furnace, closely imitating the action of a chimney. Induced draft should not be expected to create an excessive vacuum through the fuel bed itself. In case an excessive furnace draft is maintained the loss due to air leakage through the boiler setting is greatly increased. A combination system of both forced and induced draft is frequently used to good advantage where a considerable overload capacity is required of the boilers. Thus it is seen that an induced draft system is intended to either supply the draft ordinarily obtained by means of a stack, or to so increase the capacity of a stack that variable or overload capacities may be carried.

The use of mechanical draft makes a much more flexible system than does any system of natural draft, since the pressure or intensity of the draft is under perfect control of the fireman. Extreme fluctuations of load may be cared for, and peak loads that would be impossible when depending on natural draft may be readily carried.

Draft Requirement

The draft or pressure required for a boiler is due to the combined effect of two causes, the resistance of the fuel bed and the resistance of the boiler itself. In case the breeching and uptake are considered, they will cause an additional pressure loss. The amount or intensity of the draft required varies with the rate of combustion, thickness of the fuel bed, and character of the fuel used.

Boiler and economizer losses for which draft is required follow the usual law for frictional resistance. That is, other conditions remaining the same, the draft loss varies as the square of the velocity and therefore approximately as the square of the per cent. of rating developed. For example, an increase of 50 per cent. in capacity requires a draft which is 2.25 times the draft at normal rating, and for forcing to 100 per cent. overload would require four times the draft used at normal rating.

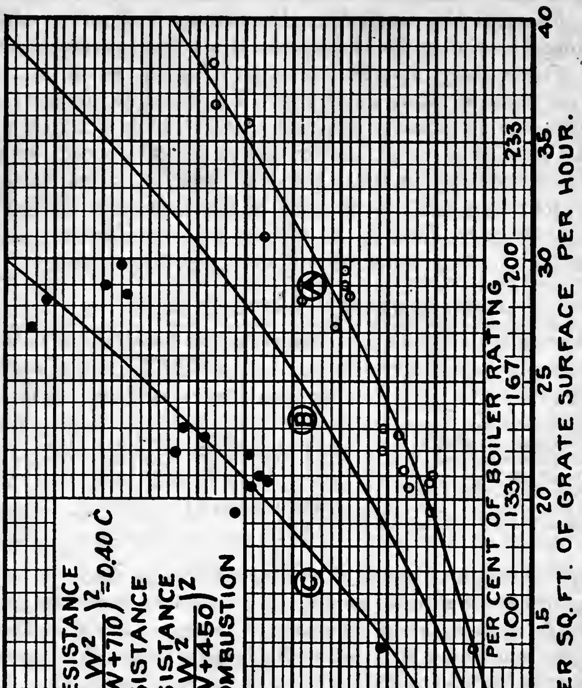
The following table gives some of the commonly accepted values for draft required in the furnace to overcome the resistance of the fuel bed under the different conditions stated:

FURNACE DRAFT IN INCHES OF WATER

	Lbs. of Dry Coal Burned per Sq. Ft. of Grate per Hr.						
	15	20	25	30	35	40	45
Eastern bituminous coal	0.12	0.16	0.20	0.27	0.34	0.42	0.52
Western bituminous coal	0.15	0.20	0.25	0.33	0.42	0.52	0.65
Semi bituminous coal	0.15	0.20	0.28	0.37	0.48	0.60	0.80
Anth. buckwheat, No. 1 and larger	0.45	0.70	1.00				
Anth. buckwheat, No. 2 and No. 3	0.75	1.30					

The diagram on page 84 shows an interesting study of draft losses at different rates of combustion, based on data furnished by Joseph Harrington of the Green Engineering Co. These tests were made on a B. & W. boiler using a Green chain grate, operating at from 50 to 250 per cent. of the rated capacity. The curve "A" shows the resistance of the fuel bed and curve "C" the total resistance of the boiler at the different rates of combustion. It was found from these curves that the fuel bed resistance was 0.4 of the total resistance. The values from curve "A" run a trifle higher than those given for furnace draft in the accompanying table.

Loss of pressure through a boiler will depend in a great measure on the condition of the surfaces in regard to soot, but ordinarily the drop in pressure through a water tube boiler may be taken as 0.25″ of water when operating at rated capacity. The loss through horizontal circular or square steel breeching will average about 0.1″ per 100 feet of length, and rectangular pipe should not depart far from a square section without increasing this value. The loss of pressure in a brick flue will be



DRAFT LOSSES FROM TESTS ON A 14 HIGH B. & W. BOILER AND GREEN CHAIN GRATE. WEST VIRGINIA COAL.

30 per cent. greater than for a steel flue. The loss of draft in an easy right angle bend or elbow will be approximately equal to 0.05″ of water. The drop in pressure through an economizer will ordinarily run from ¼ to ½ inch, at rated capacity.

Draft intensity of a chimney is proportional to its height. For a chimney 100 feet high, with flue gases at 350° above the outside temperature, the draft intensity will average approximately 0.5″ of water.

Amount of Air Required

In estimating the amount of air to be supplied, as also the size of fan required, for a forced draft system it is necessary to assume both the rate of combustion and of evaporation for the plant under consideration. These will depend on the size of the plant and the class of equipment installed. The weight of air actually required for the combustion of one pound of coal is approximately 12 pounds, but owing to the fact that it is impossible to perfectly intermingle the air and gases rising from the grate, more air must be provided than is theoretically required. This will vary from 18 to 30 pounds depending on the installation, in the average case between 20 and 25 pounds of air per pound of combustible being allowed.

It is customary practice in selecting apparatus for mechanical draft purposes to allow for 100 per cent. excess air for hand fired boilers, or 16.70 cu. ft. of air per minute at 70° per boiler H. P. for a forced draft fan, and 32.40 cu. ft. per minute at 550° for an induced draft fan. An allowance of 50 per cent. excess air is made where the boiler is equipped with a stoker, or 11.70 cu. ft. per minute at 70° per boiler H. P. for a forced, and 22.80 cu. ft. per minute at 550° for an induced draft fan.

Assuming 20 pounds of air at 70° per pound of coal, and 4.5 pounds coal containing 11450 B. t. u. per pound with a boiler efficiency of 65 per cent. as equivalent to one boiler horsepower, gives 90 pounds of air per hour, or 20 cu. ft. per minute at 70° per boiler horsepower. Then the total horsepower of the boiler multiplied by 20 gives the required capacity of the fan with the air at 70° F. This will be the proper size for a forced draft system, but with induced draft where the fan handles the gases and excess air at flue gas temperature, due allowance must be made for the increased volume to be handled, and a larger fan chosen. A fan for this purpose should be of special design, with bearings protected from the heat of the flue gases handled.

There is a definite relation between the analysis of the flue gases passing from the boiler and the quantity of air required or supplied, and, as explained on page 89, the results of the analysis may be used to determine the amount of air or gases being handled by a forced or induced draft system. The method of taking flue gas analysis by means of the Orsat apparatus is quite generally understood, and will be found described in the various standard works on boiler performance.*

A pound of carbon requires for complete combustion 2.67 pounds of oxygen, or a volume of 32.64 cu. ft. at 70°. Considered at 70°, the gaseous product, CO_2, would occupy the same volume as did the oxygen. The volume of the carbon dioxide (CO_2), as also its proportion to the nitrogen, would be the same after combustion as had been the proportions of oxygen and nitrogen originally in the air used. Then the complete combustion of carbon, with no excess of air, would give a volumetric flue gas analysis of

Carbon dioxide.............$CO_2 = 20.91\%$
Nitrogen ....N $= 79.09\%$

If the supply of air is in excess of that required to supply the oxygen needed, the combined volumes of the carbon dioxide and oxygen are still the same as that of the oxygen before combustion. The action of hydrogen in the coal is to increase the apparent percentage of nitrogen in the flue gases. Thus the sum of the CO_2 and O_2 from flue gas analysis will not be found equal to the theoretical 20.91 per cent., but will approach this amount as the amount of excess air is increased. This is shown by the values given in the table on page 87.

Quantity of air required may be determined approximately by means of the following formula when the ultimate analysis of the fuel is known.

Pounds of air required per pound of fuel

$$= 36.56\left(\frac{C}{3} + H - \frac{O}{8}\right) \tag{36}$$

where C, H and O are per cents. by weight of carbon, hydrogen and oxygen in the fuel, divided by 100.

When the proportionate part, by weight, of the carbon in the fuel (C) is known, and also the carbon monoxide (CO), carbon

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*Experimental Engineering by R. C. Carpenter.
Steam Boiler Economy by Wm. Kent.

RELATION OF BOILER EFFICIENCY AND DRAFT REQUIREMENT TO PER CENT. EXCESS AIR

WHEN BURNING BITUMINOUS COAL

Excess Air %	From Flue Gas Analysis		Heat Carried Away in Chimney Gases %	Stack Loss Plus 10% Radiation Loss %	Efficiency of Boiler %	Lbs. Air per Lb. Combustible Burned	Pounds Gases per Lb. Combustible	Pounds Combustible Burned per Boiler H. P.	Lbs. Air per Hour per Boiler H. P.	Lbs. Gas per Hour per Boiler H. P.	Cu. Ft. Air per Minute per Boiler H. P. 70° F.	Cu. Ft. Gases per Min. per Boiler H. P.	
	Carbon Dioxide CO_2 %	Excess Oxygen O_2 %										300 Deg. F.	550 Deg. F.
0	18.2	0	10.2	20.2	79.8	12.0	13.0	2.74	32.9	35.6	7.32	10.89	14.47
20	15.1	3.6	12.1	22.1	77.9	14.4	15.4	2.81	40.5	43.4	9.01	13.35	17.74
30	13.9	5.0	13.0	23.0	77.0	15.6	16.6	2.84	44.3	47.2	9.85	14.58	19.37
40	12.9	6.1	14.0	24.0	76.0	16.8	17.8	2.88	48.4	51.3	10.77	15.88	21.10
50	12.0	7.1	14.9	24.9	75.1	18.0	19.0	2.91	52.5	55.4	11.68	17.18	22.83
60	11.2	8.0	15.8	25.8	74.2	19.2	20.2	2.94	56.5	59.4	12.57	18.45	24.52
70	10.6	8.8	16.8	26.8	73.2	20.4	21.4	2.98	60.8	63.8	13.52	19.87	26.38
80	10.0	9.5	17.7	27.7	72.3	21.6	22.6	3.02	65.3	68.3	14.53	21.28	28.28
90	9.5	10.1	18.7	28.7	71.3	22.8	23.8	3.07	70.0	73.1	15.57	22.80	30.30
100	9.0	10.6	19.6	29.6	70.4	24.0	25.0	3.12	75.0	78.1	16.68	24.39	32.40
125	7.9	11.8	21.8	31.8	68.2	27.0	28.0	3.22	87.0	90.2	19.35	28.24	37.52
150	7.1	12.7	24.2	34.2	65.8	30.0	31.0	3.32	99.6	102.9	22.16	32.27	42.88
200	5.9	14.1	29.0	39.0	61.0	36.0	37.0	3.61	130.0	133.6	28.92	42.02	55.85
250	5.1	15.1	33.5	43.5	56.5	42.0	43.0	3.84	161.0	164.8	35.81	51.94	69.02
300	4.4	15.8	38.4	48.4	51.6	48.0	49.0	4.28	205.0	209.3	45.60	66.06	87.78

dioxide (CO_2) and nitrogen (N) in per cent. by volume are determined from the flue gases, the total amount of air supplied may be found from the following formula,

Pounds of air supplied per pound of fuel

$$= 3.032 \left(\frac{N}{CO_2 + CO} \right) \times C + (1\text{-}A) \qquad (37)$$

where A represents the proportionate part, by weight, of ash in the fuel.

Ratio of air supplied per pound of fuel to the amount theoretically required is

$$\frac{N}{N - 3.782\,O} \qquad (38)$$

The heat loss in the flue gases is

$$H = 0.24\,W\,(T\text{-}t) \qquad (39)$$

where H = B. t. u. lost per lb. of fuel.
W = Wt. of flue gas in lb. per lb. fuel.
T = Temperature of flue gas deg. F.
t = Temperature of air deg. F.
0.24 = specific heat of flue gas.

The table on page 87 has been calculated on the basis of burning a good grade of bituminous coal having a combustible containing 87 per cent. carbon and 5.5 per cent. hydrogen. The amount of CO in the flue gas has been considered a negligible quantity, and only the CO_2 and O_2 used in the calculations. This table gives the air required for different dilution coefficients and the air quantities to be allowed for either forced or induced draft work when operating with different amount of excess air. It also gives the per cent. of excess air corresponding to different per cents. of excess oxygen as determined from the flue gas analysis. This may be readily calculated from the formulae on page 89. As explained on page 89 under air measurement, the values in this table give a measure of the air being handled when the flue gas analysis and also either the weight of combustible burned or of water evaporated are known.

On page 87 the column of air quantity at 70° per H. P. would apply to forced draft work; the column headed 300° would apply to the average induced draft conditions where an economizer was in use, while the column headed 550° would be used for induced draft fans handling gases directly from the boiler. These values then indicate the increase in volume of a given weight of air at a constant pressure for the different temperature conditions.

The tables on pages 321 to 330 give the capacity under different conditions, both for standard and for special high efficiency fans when used for induced draft service. The standard Planoidal, Niagara Conoidal and Turbo-Conoidal fan capacity tables in Part IV, Section III, give the required information for forced draft work.

Measurement of Air Used

Amount of air being used by either forced or induced draft systems under different conditions may be determined by either of the three following methods:

1—Pitot tube readings in the breeching or forced draft connection.

2—By weighing the coal and ash and taking the flue gas analysis.

3—Approximately by weighing the water and taking the flue gas analysis, in case of a boiler with a good setting.

The theory and method of using the pitot tube will be found fully given on page 190 under "Fan Testing" and need not be repeated here. If intelligently used this instrument has proven itself to be a simple and accurate method of measuring air or gases. It may be used alone or as a check on either of the other two methods mentioned, and in the case of a forced draft system any difference between determinations made by the pitot tube and from the flue gas analysis would be an indication of air leakage through the boiler setting.

Amount of air used in per cent. of that theoretically required may be determined from the proportions of excess oxygen and carbon dioxide as indicated by the flue gas analysis. The relation between these three factors may be expressed by the following formulae, where O_2 = excess oxygen and CO_2 = carbon dioxide from the flue gas analysis, and K = per cent. of excess air being used.

$$K = \frac{96.6\ O_2}{20.9 - O_2} \qquad (40)$$

$$K = \frac{1760}{CO_2} - 96.6 \qquad (41)$$

Theoretical amount of O_2 or CO_2 in the flue gas for any per cent. of excess air may be found from the following:

$$O_2 = \frac{20.9\frac{K}{100}}{0.966 + \frac{K}{100}} \qquad (42)$$

$$CO_2 = \frac{17.60}{0.966 + \frac{K}{100}} \qquad (43)$$

Since it requires approximately 12 pounds of air to burn one pound of combustible, in case K as derived from the formulae shows 100 per cent. excess air, we would know at once that 24 pounds of air were being supplied for each pound of combustible burned, or that 25 pounds of gases were being handled if an induced draft system was installed. The table on page 87 gives the pounds of air required per pound of combustible burned for different amounts of excess oxygen in the flue gas.

The table just referred to also shows the cubic feet of air and of chimney gases per boiler H. P. for the different flue gas analyses. Thus we see that if the H. P. developed is known from the weight of water evaporated, the flue gas analysis gives an indication of the amount of air used. Any determinations of this character are subject to corrections on account of varying amounts of leakage through the boiler setting.

Mechanical Draft in Connection with Mechanical Stokers

Mechanical draft may be used in connection with boilers fitted with automatic stokers as readily as with hand fired installations. With some forms of stokers either forced or induced draft may be used while others are only adapted to forced draft, or in some special instances to some form of steam jet blower.

The manufacturers of the Parsons Mechanical Stoker ordinarily install a steam jet blower in connection with their apparatus, although if conditions will permit, forced draft by means of a fan may be used. Their practice is to allow for maximum conditions a pressure in the ash pit of 2¾ inches for anthracite, 1¼ inches for bituminous coking coals, and 1 inch for non-coking coals. The damper regulators are ordinarily so adjusted as to give a maximum indraft if 0.05 of an inch over the fire, or a condition of minimum inflow at the fire doors or corresponding parts. In special double deck boilers this may be increased to 0.15 of an inch.

Forced draft is used in connection with the Jones underfeed stoker system, sufficient pressure being maintained to force the air required for combustion into the air chamber and practically to the top of the fuel bed. The stack is then depended upon to produce the necessary furnace draft and to overcome the resistance through the boiler. To meet the maximum requirements it is customary to provide for supplying 200 cu. ft. of air per pound of coal at a pressure of not less than two ounces in the air chamber. For approximating the probable coal consumption the company's engineers ordinarily assume five pounds of coal per horsepower which will provide a sufficiently large factor of safety and allow for some reserve power. This allows 16.67 cu. ft. of air per minute per boiler horsepower.

Forced draft is used in connection with the Taylor stoker, giving a very wide range of over capacity to the boiler. The pressure required in the tuyere chamber may vary from one to six inches of water according to the conditions and capacity developed. Recent tests on a well known installation of Taylor stokers, with the boilers using an average of approximately 35 per cent. excess air, required the following pressures in inches of water in the tuyere chamber for the corresponding per cent. of rated boiler capacity.

TAYLOR STOKERS

Per Cent. of Rated Boiler Capacity	Air Pressure in Tuyere Chamber
100	1.10 in.
125	1.70 in.
150	2.50 in.
175	3.40 in.
200	4.50 in.

The Murphy automatic smokeless furnace may be used with either forced or induced draft, giving an overload capacity to the boiler. As an instance of this a test on 500 H. P. of water-tube boilers may be cited in which a maximum natural draft of 0.45 inch to 0.50 inch above the fire gave a capacity of about 115 to 120 per cent. above normal rating. With a pressure of from ¾ inch to 1 inch under the fire the draft suction above the fire was reduced to about 1 to 2 hundredths of an inch and the capacity raised to 200 per cent. above the rating.

Draft requirements in connection with the various chain grates, such as the Green or the B. & W. will not differ materially from each other, or from a stationary grate if it is kept clean and free from clinker, and an interesting study of results obtained from such an installation will be found on page 84. This data was furnished by Joseph Harrington, Chief Engineer of the Green Engineering Company, based on actual tests under the conditions stated. While no one set of curves will give the draft losses for all the various kinds of coal or all the different types of boilers, yet a diagram such as the one referred to is of especial value inasmuch as it gives a basis for a comparative study of other conditions.

Niagara Conoidal Type "N" Fan Direct Connected to Buffalo Double Vertical, Double-Acting Engine

SECTION V

EXHAUST SYSTEMS

An extensive field has been developed for the use of exhaust fans of more or less special design, for the removal of refuse and industrial waste in shops and factories, as well as removing the heated or foul air, or gases, resulting from various industrial processes. Such an exhaust system consists of the proper hood or receptacle at the receiving end, the necessary piping to connect to the exhaust fan, and if refuse is handled, some form of dust or refuse collector. In laying out an exhaust or conveying system the usual method of procedure is to determine: (1) the number and size of branch pipes necessary to properly do the work; (2) the design and arrangement of piping to give the best results with the least power consumption; (3) the size and most economical type of exhaust fan, and (4) the disposition of refuse.

Size of Pipe

Proper size of piping required is for the most part a matter of experience, although practice has established standards for the more common applications. The tables on page 94 give the usual sizes of galvanized iron piping to attach to the hoods of the machines indicated. For branch pipes over 25 feet long, increase the size 10 per cent. for each additional 20 feet.

Hood Construction

It is almost impossible to give standard practice in hood construction, since there is such a variety of makes and sizes of machines as to obviate the possibility of having any standard design. Furthermore, a hood must be constructed to suit the character of the work to be done. In designing hoods, a principle to keep in mind is to so shape them that the refuse from knives or wheels, due to their centrifugal action, is thrown directly to a point where it will be caught by the highest velocity of air. Hoods should always be made to fit as tight and close as possible, since the suction effect is lost, resulting in poor operation, if this feature is disregarded.

PIPE SIZES FOR WOODWORKING MACHINES

	No. of Pipes	Size of Pipes		No. of Pipes	Size of Pipes
Cut-off Saws,			Matcher Heads, each	1	5
10-16 inch diameter	1	4	Moulder	4	4-7
18-24 inch diameter	1	5	Sash and Cabinet Shaper	1	4
Rip Saws and Re-Saws,			Door Tenoner...........	1	5
10-16 inch diameter	1	4	Sash Tenoner	1	4
18-24 inch diameter	1	5	Sticker, each head.......	1	4
24-60 inch diameter	1	6	Panel Raiser, each head..	1	4
Band Saws, small	1	3	Mortiser................	1	6
Buzz Planer	1	4-7	Router..................	1	4
Pony Planer	1	4-7	Jointer..................	1	4-7
Diagonal Planer........	1	4-7	Sand Drum, 24 inch long.	1	4
Four Sided Planer......	4	4-7	Sand Drum, 30 inch long.	1	5
Bull Planer............	2	4-7	Sand Belt	1	4
Planer and Matcher	4	4-7	Floor Sweeps		6

Sizes of pipes for planers, moulders and similar machines with knives or saws.

UPPER KNIVES		LOWER KNIVES	
Length, Inches	Size of Pipe, Inches	Length, Inches	Size of Pipe, Inches
5	4	5	4
10	5	10	5
14	6	14	5
24	7	24	6
30	7	30	7

For planers handling timber the pipe sizes must be increased 25 per cent. High speed planers and matchers require about 50 per cent. more area than indicated in the above table.

PIPE SIZES FOR EMERY WHEEL EXHAUST SYSTEMS

Diameter of Wheel, Inches	Size of Pipe, Inches	Diameter of Wheel, Inches	Size of Pipe, Inches
36	7	20	4½
30	6	16	4
26	5	12	3½

For the removal of smoke or fumes it is good practice to make the mouth of the hood extend out over the kettle or furnace at least six inches in every direction, if the hood is not elevated over two feet. For every additional two feet elevation, the size of the hood should be increased six inches each way. The area of the branch pipe should then be made one-sixteenth of the hood mouth. For instance, a furnace 2 x 4 feet in size, having the bottom of the hood four feet above it, would have a hood 4 ft. x 6 ft. and the area of the pipe should be one-sixteenth of this, or 1.5 sq. ft. This branch should therefore be 17 inches in diameter. The velocity at the mouth for average conditions should be 75 to 250 feet per minute.

In some manufacturing processes it will be found necessary to provide some means for the removal of poisonous and noxious gases that will be more certain in its action than is the common form of open hood or canopy. This can be accomplished by the use of a double hood with about an inch or less of clearance between the edges of the outside and inside hoods. There should also be an opening in the top of the inner hood, located under the exhaust pipes. These openings should be of such a size that a velocity of about 1000 feet per minute will be created through the slot, around the edge and through the central opening.

Size of Main Pipe

It is the common practice in blow-pipe construction to add the area of the branch pipes and make the area of the main pipe equal to their sum. This process should be continued back to the fan, choosing a fan with an inlet equal to or greater in area than the main pipe.

Velocity Required

The subject of the proper velocity of the air throughout the system is an important one, and while sufficient velocity should be provided to insure the removal of the material being handled, any excess means an unnecessary increase in power consumption. It must be borne in mind that the power required increases as the cube of the speed or velocity, hence to double the velocity will require eight times the horsepower.

In planing-mill work, it is customary to allow a velocity of 2400 for light shavings, 3000 for dry saw dust, and from 3600 to 4000 for knots, blocks, etc. This corresponds to operating the exhaust fan at a speed to give approximately 2½ to 5 ounces of pressure, depending upon the length of the piping and the velocity required. The velocity in the piping should either be uniform throughout the entire system, or else higher in the branches than in the main pipe.

Dust Removal from Grinding and Buffing Wheels

Specifications for the design, construction and operation of exhaust systems for grinding, polishing and buffing wheels to comply with the Labor Law of New York State, have been prepared by William Newell, of the Department of Labor, as follows: Accompanying the specifications are certain recommendations by The Buffalo Forge Company on the design of these systems.

1. Minimum size of branch pipes allowed for different sized emery or other grinding wheels are given in the accompanying table. In case a wheel is thicker than given in the tabulation, or if a disc instead of a regular wheel is used, it must have a branch pipe no smaller than is called for by its grinding surface.

GRINDING WHEELS

Diameter of Wheels	Maximum Grinding Surface, Sq. Ins.	Minimum Diameter of Branch Pipe in Inches
6″ or less, not over 1″ thick	19	3
7″ to 9″ inclusive, not over 1½″ thick	43	3½
10″ to 16″ inclusive, not over 2″ thick	101	4
17″ to 19″ inclusive, not over 3″ thick	180	4½
20″ to 24″ inclusive, not over 4″ thick	302	5
25″ to 30″ inclusive, not over 5″ thick	472	6

BUFFING WHEELS

Diameter of Wheels	Maximum Grinding Surface, Sq. Ins.	Minimum Diameter of Branch Pipes in Inches
6″ or less, not over 1″ thick	19	3½
7″ to 12″ inclusive, not over 1½″ thick	57	4
13″ to 16″ inclusive, not over 2″ thick	101	4½
17″ to 20″ inclusive, not over 3″ thick	189	5
21″ to 24″ inclusive, not over 4″ thick	302	5½
25″ to 30″ inclusive, not over 5″ thick	472	6½

2. Minimum sizes of branch pipes allowed for different sized buffing, polishing, or rag wheels, as they are variously called, are given in the table.

Buffing wheels six inches or less in diameter used for jewelry work may have a three-inch branch pipe.

The thickness given for buffing wheels applies to the thickness of the wheel at the center. In case the wheel is thicker than given in the tabulation, it must have a branch pipe no smaller than is called for by its grinding surface.

3. Branch pipes must not be less than the sizes specified above throughout their entire length.

4. All branch pipes must enter the main suction duct at an angle not exceeding 45°, and must incline in the direction of the air flow at junction with main.

5. Branch pipes must not project into the main duct.

6. All laps in piping must be made in the direction of the air flow.

7. All bends, turns, or elbows, whether in the main or branch pipes, must be made with a radius in the throat at least equal to 1½ times the diameter of the pipe on which they are connected.

8. The inlet of the fan or exhauster shall be at least 20 per cent. greater in area than the sum of the areas of all the branch pipes, and such increase shall be carried proportionately throughout the entire length of the main suction duct, i. e., the area of the main at any point shall be at least 20 per cent. greater than the combined areas of the branch pipes entering it between such point and the tail end or dead end of the system.

For the convenience of those wishing to use it, the table on page 98 is given, showing what the size of the main suction duct should be at any point for any number of uniform-size branch pipes when the main duct is made 20 per cent. greater than the combined areas of the branches entering it,—the minimum required by these specifications.

9. The area of the discharge pipe from the fan shall be as large or larger than the area of the fan inlet throughout its entire length.

10. The main trunk lines, both suction and discharge, shall be provided with suitable clean-out doors not over ten feet apart, and the end of the main suction duct shall be blanked off with a removable cap placed on the end.

PROPORTIONS OF MAIN DUCT TO ACCOMMODATE BRANCHES

Number of Branch Pipes	Diameter of Branch Pipes in Inches								
	3	3½	4	4½	5	5½	6	6½	7
	Area of Each Branch Pipe in Square Inches								
	7.07	9.62	12.566	15.9	19.635	23.758	28.274	33.183	38.485
	Area of Each Branch Pipe Plus 20% (Square Inches)								
	8.484	11.544	15.08	19.08	23.562	28.51	33.93	39.82	46.182
1	3⅜	3⅞	4⅜	5	5½	6	6⅝	7⅛	7¾
2	4¾	5½	6¼	7	7¾	8⅝	9¼	10⅛	10⅞
3	5¾	6⅝	7⅝	8⅝	9½	10½	11½	12⅜	13¼
4	6⅝	7¾	8¾	9⅞	11	12⅛	13⅛	14¼	15⅜
5	7⅜	8⅝	9⅞	11	12¼	13½	14¾	16	17⅛
6	8⅛	9½	10¾	12⅛	13½	14¾	16⅛	17½	18¾
7	8¾	10¼	11⅝	13⅛	14½	16	17½	18⅞	20¼
8	9⅜	10⅞	12⅜	14	15½	17⅛	18⅝	20⅛	21¾
9	9⅞	11½	13⅛	14⅞	16½	18⅛	19¾	21⅜	23
10	10½	12⅛	13⅞	15⅝	17⅜	19⅛	20¾	22½	24¼
11	11	12¾	14⅝	16⅜	18¼	20	21⅞	23⅝	25½
12	11½	13⅜	15¼	17⅛	19	20⅞	22¾	24¾	26⅝
13	11⅞	13⅞	15⅞	17⅞	19¾	21¾	23¾	25¾	27¾
14	12⅜	14⅜	16½	18½	20½	22⅝	24⅝	26¾	28¾
15	12¾	14⅞	17	19⅛	21¼	23⅜	25½	27⅝	29¾
16	13¼	15⅜	17⅝	19¾	22	24⅛	26⅜	28½	30¾
17	13⅝	15⅞	18⅛	20⅜	22⅝	24⅞	27⅛	29⅜	31⅝
18	14	16⅜	18⅝	21	23¼	25⅝	27⅞	30¼	32⅝
19	14⅜	16¾	19⅛	21½	23⅞	26¼	28¾	31⅛	33½
20	14¾	17⅛	19⅝	22⅛	24½	27	29½	31⅞	34⅜
21	15⅛	17⅝	20⅛	22⅝	25⅛	27⅝	30⅛	32¾	35⅛
22	15½	18	20⅝	23⅛	25¾	28⅜	30⅞	33½	36
23	15¾	18½	21⅛	23¾	26⅜	29	31½	34¼	36¾
24	16⅛	18⅞	21½	24¼	26⅞	29⅝	32¼	34⅞	37⅝
25	16½	19¼	22	24¾	27½	30⅛	32⅞	35⅝	38⅜
26	16¾	19⅝	22⅜	25⅛	28	30¾	33½	36⅜	39⅛
27	17⅛	20	22⅞	25⅝	28½	31⅜	34⅛	37	39⅞
28	17½	20⅜	23¼	26⅛	29	32	34¾	37¾	40⅝
29	17¾	20¾	23⅝	26⅝	29½	32½	35½	38⅜	41⅜
30	18	21	24	27	30	33	36	39	42

11. Sufficient static suction head shall be maintained in each branch pipe within one foot of the hood to produce a difference in level of two inches of water between the two sides of a U-shaped tube. Test is to be made by placing one end of a rubber tube over the small hole made in the pipe, the other end of the tube being connected to one side of a U-shaped water gauge. Test is to be made with all branch pipes open and unobstructed.

In addition to the foregoing specifications, which are compulsory, a number of "Recommendations" are given below, which, if observed, will make for still more efficient operation and longer life of the system.

Recommendations

1. Emery wheel and buffing wheel exhaust systems should be kept separate owing to danger of sparks from the former setting fire to the lint dust from the latter, if both are drawn into the same suction main.

2. In the case of undershot wheels, i. e., the top of the wheel runs toward the operator, which is almost always the direction of rotation of both emery and buffing wheels, the main suction duct should be back of and below the wheels and as close to them as is practicable; or it should be fastened to the ceiling or the floor below, preferably the former. If behind the wheels, it should be not less than six inches above the floor at every point to avoid possible charring of the floor in case of fire in the main duct and also to permit sweeping under it. For similar reasons it should be at least six inches below any ceiling it may run under.

3. Both the main suction and discharge pipes should be made as short and with as few bends as possible, to avoid loss by friction. If one or the other must be of considerable length, it is best to place the fan not far beyond where the nearest branch enters the large end of the main, as a long discharge main is a lesser evil than a long suction main.

4. Avoid any pockets or low places in ducts where dust might accumulate.

5. The main suction duct should be enlarged between every branch pipe entering it, whenever space permits, and in no case should the main duct receive more than two branches in a section

of uniform area. All enlargements in the size of the main should be made on a taper and not by an abrupt change.

6. If there is a likelihood of a few additional wheels being installed in the future, it is advisable to leave a space for them between the fan and the first branch and to put in an extra size fan. Or, a space may be left beyond the fan so that the fan may be moved along and the main extended when it is actually decided to install additional wheels, provided the fan is of sufficient size to still comply with these specifications after the additional branches are added.

7. Branch pipes should enter the main on the top or sides —never at the bottom. Two branches should never enter a main directly opposite one another.

8. Each branch pipe should be equipped with a shut-off damper or blast-gate as it is also called, which may be closed, if desirable, when the wheel is not in use. Not more than 25 per cent. of such blast-gates should be closed at one time; otherwise, the air velocity in the main duct may drop too low and let the dust accumulate on the bottom.

9. It is very important that the lower part of the hood shall come far enough forward beneath the front of the wheel so that the dust will enter the hood and not fall outside of it altogether, even if the accomplishment of this result necessitates leaving considerable space between the wheel and the lower part of the hood in order that the hood shall not interfere with the work.

10. Branch pipes should lead out of the hood as nearly as possible at the point where the dust will naturally be thrown into them by the wheels. This is very important.

11. An objectionable practice sometimes found where small work is polished is the use of a screen across the mouth of the branch pipe where it enters the hood. Such screens are an obstruction to the passage of material, and the ravelings from buffing wheels are held against the screen by the suction, with the result that in a short time the draft is almost entirely cut off.

12. The use of a trap at the junction of the hood and branch pipe is good practice provided it is cleaned out regularly and not allowed to fill up with dust. This will catch the heavier particles and so take some wear off the fan. It will also serve to catch any nuts, pieces of tripoli, etc., dropped by accident,

and in the case of work on small articles, will enable them to be recovered when dropped in the hood.

13. All bends, turns, or elbows, whether in the main or branch pipes, should be made with a radius in the throat of twice the diameter of the pipe on which they are connected, wherever space permits.

14. Elbows should be made of metal one or two gauges heavier than the pipe on which they are connected as the wear on them is much greater.

15. The withdrawal of air from a room by an exhaust system naturally tends to create a slight vacuum and for this reason inlets for air at least equal to the sum of the areas of the branch pipes should be left open.

16. Recommendations for the size of the cyclone separator or dust collector, as it is often called, are hard to give, as the separator must be proportioned to suit operating conditions, light dusts requiring a larger separator than heavier dusts. A separator should be selected with an inlet area at least as large as the area of the discharge pipe from the fan.

For light buffing dusts, lint, etc., the air outlet from the top of the separator should be so large that the velocity of discharge will not exceed 300 to 480 feet per minute; then select a separator of which the other dimensions are proportionate. The air outlet should be provided with a proper canopy or elbow to exclude the weather, but should be otherwise unobstructed.

DIMENSIONS OF DUST COLLECTORS

Diam. Inlet	Diam. Air Outlet	Diam. Dust Outlet	Diam. Collector	Total Height	Diam. Inlet	Diam. Air Outlet	Diam. Dust Outlet	Diam. Collector	Total Height
6	12	6	24	40	28	56	14	112	175
8	16	7	32	52	30	60	15	120	187
10	20	8	40	64	32	64	16	128	200
12	24	8	48	76	34	68	17	136	212
14	28	8	56	89	36	72	18	144	224
16	32	8	64	101	38	76	19	152	236
18	36	9	72	114	40	80	20	160	248
20	40	10	80	126	42	84	21	168	260
22	44	11	88	139	44	88	22	176	272
24	48	12	96	151	46	92	23	184	284
26	52	13	104	163	48	96	24	192	296

Dust Collectors

The air with its contents of shavings and dust should be delivered by the fan into a separator or collector. Whatever heavy matter the air carries here settles to the bottom and is discharged into the proper receptacle, leaving the air to escape to the atmosphere. As usually built they depend on the centrifugal action to accomplish the separation. While the different makes will vary in their dimensions, the table on page 101 will serve to give a general idea of the sizes used. These are built either right or left hand.

A properly designed separator should not cause a resistance of more than one velocity head due to the flow. That is, with a velocity of 4000 feet per minute the resistance would be one inch.

Friction Loss

A complete discussion on the loss in pressure due to friction of the air passing through the piping and elbows will be found on pages 115 to 120. For perfectly smooth piping we may consider that one velocity head, or a pressure corresponding to the velocity, is lost in every 60 diameters of pipes, but for planing-mill work it is customary to use a factor of 55 diameters. That is, with a velocity through the pipes of 4000 feet per minute, which corresponds to a pressure or velocity head of one inch, there would be one inch of pressure lost in every 55 diameters. With a pipe 18 inches in diameter, one velocity head would be lost in each 83 feet of length. The fan must operate at a total pressure sufficient to care for all of the losses, and still leave a pressure corresponding to the velocity desired. For the loss in elbows see the diagrams on pages 118 and 119.

Standard and Slow Speed Planing-Mill Exhausters

For conveying refuse from wood working machines and carrying off factory waste of similar nature, fans with steel plate housings and overhung blast wheels are usually employed. These fans are of heavier construction than those used for ventilating, and are built double as well as single for use where a double fan avoids unnecessary length of piping and elbows. A description of these fans and capacity tables will be found in Part IV, Section III. In the ordinary planing-mill the refuse is sufficient to furnish fuel for heating and power. The standard type fan is designed for large capacity, rather than for high efficiency, so wherever it is necessary to buy fuel, a more efficient fan should be used, and proper design makes it possible to combine the features of high efficiency and slow speed. The most efficient type of slow speed planing-mill exhauster has a housing which is very large and narrow in proportion to the size of inlet and outlet connections, and will reduce the power at least 15 per cent. while operating at about two-thirds the speed of the standard fan. Dimension and capacity tables of these fans will be found in Part IV, Section III.

Primarily, the speed of the fan depends upon the suction or vacuum to be maintained at the hoods. To move shavings and saw dust, a velocity in the piping system of from 3000 to 4000 feet per minute is the average requirement, which corresponds approximately to 1⅛ to 2 inches suction in the pipe near the hood inlets, and a velocity head in the piping of from 0.6 to 1.0 inch. In addition to maintaining this suction at the hoods, the operating pressure at the fan must be sufficient to overcome the friction losses of the system. Piping friction losses, plus collector loss, plus intake and discharge losses, therefore equals the necessary operating pressure of the exhauster.

Examples. As an example, take a planing-mill installation having three 7-inch branch pipes, three 6-inch branch pipes, two 5-inch branch pipes and one 4-inch branch pipe. Assume that the longest run of piping on the suction side of the fan is 57 feet, that there are three right angle elbows in the same (radius of elbows 1½ diameters), and that the fan discharges its refuse into a collector located 60 feet from the fan, with one right angle elbow in this pipe.

Adding the areas of branch pipes, the diameter of the main suction pipe will be 18 inches. Referring to the data on friction losses on page 102 the loss in 55 diameters of pipe equals one velocity head.

57 feet of suction and 60 feet of discharge piping (1½ foot diameter) is equivalent to

$$\frac{57+60}{1\frac{1}{2}}=78 \text{ diameters}$$

Referring to the curve of friction loss in round elbows on page 118 it will be seen that the loss in each of the four elbows will be 0.17 of a velocity head. For a perfectly smooth well built system this would mean each elbow was equivalent in friction to 9.5 diameters of pipe, but it is the general custom to allow ten diameters to each elbow. We will then have the four elbows equal to 40 diameters, in addition to the 78 diameters of piping. Allowing the customary 55 diameters as equal to one velocity head lost we have as the loss in the piping and elbows

$$\frac{78 + 40}{55} = 2.15 \text{ velocity heads.}$$

Intake and discharge loss = 1.5 velocity heads.

Loss in refuse collector = 1 velocity head.

Pressure due to the velocity = 1 velocity head.

Total operating head = 5.65 velocity heads.

Assume 4000 feet velocity required, which corresponds to a pressure of one inch or 0.5768 ounces per square inch.

The necessary operating pressure of exhauster will then be $5.65 \times 0.5768 = 3.25$ ounces.

From the dimension and capacity tables, an exhauster having an 18-inch inlet, or the 45-inch size should be used. If a slow speed exhauster were chosen we would find from the table on page 345 that for 3 oz. pressure the necessary speed would be 742 R. P. M., the capacity 6620 cu. ft. per minute and the power required 8.97 H. P. But as the pressure required is 3.25 oz. the accompanying conditions must be calculated from the above factors. That is,

$$\text{the speed will be } 742\sqrt{\frac{3.25}{3.00}} = 770 \text{ R. P. M.}$$

$$\text{the capacity will be } 6620\sqrt{\frac{3.25}{3.00}} = 6880 \text{ cu. ft. per min.}$$

$$\text{and the power will be } 8.97\sqrt{\left(\frac{3.25}{3.00}\right)^3} = 10.10 \text{ H. P.}$$

If a standard exhauster is used the speed will be 1245 R.P. M.; the capacity the same as above; and the power 12.15 H. P. The power as stated would be maximum, that is, the amount required when all the branch pipes are open. In pattern shops, all of the machines are seldom used at once, which means that less air is handled, with resultant reduction in power.

The capacity tables on pages 343 and 346 which have been compiled with velocity as a basis, will be found more convenient in computing speed and powers than the above method and for most installations will be sufficiently accurate. Assuming the same conditions as in the preceding problem, an example of their use follows:

Length of suction and discharge pipe, 117 feet.

Length of pipe equivalent to four elbows equals
$4 \times 10 = 40$ diameters.

40 diameters × $1\frac{1}{2} = 60$ feet.

Length of pipe equivalent to collector equals one velocity head or 55 diameters.

55 diameters × $1\frac{1}{2} = 83$ feet.

Total equivalent length = 260 feet.

The tables are based on an assumption that the system will contain an equivalent of 275 feet of piping, and corrections for 15 feet will be necessary. For each 10 feet difference, the speed must be decreased one per cent., or 1.5 per cent. in this instance, and the power three per cent., or $3 \times 1.5 = 4.5$ per cent.

From tables, pages 343 and 346, the following is obtained:

Slow speed exhauster—Speed 790 less $1\frac{1}{2}\% = 778$ R. P. M. Power 11.1 less $4\frac{1}{2}\% = 10.60$ H. P.

Standard exhauster—Speed 1295 less $1\frac{1}{2}\% = 1275$ R. P. M. Power 13.3 less $4\frac{1}{2}\% = 12.70$ H. P.

SECTION VI

MISCELLANEOUS APPLICATIONS

Fans are used for a great variety of purposes, many of which have special engineering features which make it impossible to lay down any easily applied rules for their installation. Even where a standard fan is to be used, a full knowledge of all of the features of the case are necessary before making a selection.

One large field for the use of fans, propellors and disk wheels is in connection with drying and cooling work, a brief discussion of which is given in the following pages. Fans and blowers are used for many purposes requiring air under considerable pressure, such as foundry and furnace service; blast supply for forges; for sand blast machines, pneumatic tube installations, mine ventilation, tunnel work, in glass factories, and many other special applications.

For forge service either the volume blowers listed in the table on page 335 may be used, or the pressure blowers already mentioned, depending on the conditions. For exhausting the smoke and gases from forges a pressure of from one to two ounces is required. The blast is usually run at three to six ounces pressure. Piping should be properly proportioned to allow for friction.

Special blowers and exhausters, either low or high pressure, are built for handling gas at gas works, or for removing acid or other chemical fumes. These latter may be made of special acid-resisting metals. For gas works the low pressure exhausters range in capacity from 30,000 to 1,500,000 cubic feet per hour at a pressure up to 15 inches of water. High pressure exhausters range in capacities from 30,000 to 3,000,000 cubic feet of air.

In connection with blast furnaces a special gas cleaning fan is used, in which the inner surface is kept wet by sprays. The centrifugal force throws the dust particles against the water covered surface of the interior of the fan, so cleansing the gas. In the case of gas producers the same form of fan, or gas scrubber, is used to remove the tar from the gas.

Forge Shop Equipment

Table on page 107 gives sizes of blast and exhaust fans for School Forge Shops and table on page 108 sizes of blast and exhaust tile.

FORGE SHOP EQUIPMENT

Sizes of Fans Required for School Forge Shops

		Blast						Exhaust					
			Steel Press. or B Vol. Blower						Exhaust Fan at 1 ½ Oz. B Vol. or Planoidal St. Pl. Exhauster				
Press. of Blast	Num. of Buffalo OJD Forges	Diam. Main Blast Duct	Blower Size	Diam. Outlet	A. P. M. per Forge	R. P. M.	H. P.	Diam. Main Exh. Duct	Fan Size	Diam. Inlet	A. P. M. per Forge	R. P. M.	H. P.
2½ Oz. per Sq. In.	1	3"	3 S. P. B.	4¾"	430	3150	0.73	6"	2 B Vol.	6 1/16"	458	2420	0.34
	2	4"	3 S. P. B.	4¾"	215	3150	0.73	9"	4 B Vol.	9"	507	1490	0.76
	3	5"	3 S. P. B.	4¾"	143	3150	0.73	10"	5 B Vol.	10⅝"	485	1345	1.09
	4	6"	3 S. P. B.	4¾"	107	3150	0.73	12"	6 B Vol.	11 13/16"	515	1100	1.54
	5	7"	3 S. P. B.	4¾"	86	3150	0.73	14"	30" Pl.	15"	470	1410	2.08
	6	8"	3 S. P. B.	4¾"	72	3150	0.73	15"	35" Pl.	17½"	530	1210	2.82
	7	8"	3 S. P. B.	4¾"	61	3150	0.73	16"	40" Pl.	20"	595	1060	3.68
	8	9"	4 S. P. B.	5"	58	2660	0.78	17"	40" Pl.	20"	520	1060	3.68
	9	9"	5 S. P. B.	5⅜"	57	2330	0.88	18"	45" Pl.	22½"	585	943	4.66
	10	10"	3 B Vol.	7⅝"	93	2195	1.23	19"	45" Pl.	22½"	527	943	4.66
	11	10"	3 B Vol.	7⅝"	90	2195	1.23	20"	50" Pl.	25"	590	848	5.78
	12	11"	3 B Vol.	7⅝"	82	2195	1.23	21"	50" Pl.	25"	540	848	5.78
3 Oz.	13	11"	3 B Vol.	7⅝"	84	2414	1.62	22"	50" Pl.	25"	500	848	5.78
	14	11"	3 B Vol.	7⅝"	78	2414	1.62	23"	55" Pl.	27½"	560	772	6.99
	15	12"	3 B Vol.	7⅝"	73	2414	1.62	23"	55" Pl.	27½"	525	772	6.99
	16	12"	3 B Vol.	7⅝"	68	2414	1.62	24"	55" Pl.	27½"	490	772	6.99
	17	12"	3 B Vol.	7⅝"	64	2414	1.62	25"	60" Pl.	30"	550	707	8.30
	18	13"	3 B Vol.	7⅝"	60	2414	1.62	26"	60" Pl.	30"	520	707	8.30
	19	13"	3 B Vol.	7⅝"	57	2414	1.62	26"	60" Pl.	30"	490	707	8.30
	20	14"	3 B Vol.	7⅝"	55	2414	1.62	27"	60" Pl.	30"	460	707	8.30
3½ Oz.	21	14"	3 B Vol.	7⅝"	55	2590	2.03	28"	70" Pl.	35"	610	606	11.3
	22	14"	4 B Vol.	9"	70	2270	2.72	28"	70" Pl.	35"	580	606	11.3
	23	15"	4 B Vol.	9"	67	2270	2.72	29"	70" Pl.	35"	555	606	11.3
	24	15"	4 B Vol.	9"	65	2270	2.72	30"	70" Pl.	35"	530	606	11.3
	26	15"	4 B Vol.	9"	60	2270	2.72	31"	70" Pl.	35"	490	606	11.3
	28	16"	4 B Vol.	9"	55	2270	2.72	32"	80" Pl.	40"	595	530	14.8
	30	16"	4 B Vol.	9"	52	2270	2.72	33"	80" Pl.	40"	555	530	14.8

SIZE OF BLAST AND EXHAUST TILE FOR FORGE SHOP EQUIPMENT

Sizes of Branch Tile	Blast Tile		Exhaust Tile		
	3″	4″	6″	8″	10″
No. of Branch Tile	Size of Main Tile				
1	3	4	6	8	10
2	4	6	9	12	15
3	5	8	12	15	18
4	6	8	12	18	20
5	6	8	15	18	24
6	8	9	15	20	27
7	8	10	18	24	27
8	8	12	18	24	30
9	9	12	18	24	30
10	9	12	20	30	36
11	9	12	20	30	36
12	10	15	20	30	36
13	10	15	24	30	36
14	10	15	24	30	40 x 32
15	12	15	24	36	40 x 32
16	12	15	24	36	40 x 32
17	12	15	27	36	40 x 36
18	12	18	27	36	40 x 36
19	12	18	27	36	40 x 40
20	15	18	27	36	40 x 40
21	15	18	30	40 x 32	44 x 44
22	15	18	30	40 x 32	44 x 44
23	15	18	30	40 x 32	44 x 44
24	15	18	30	40 x 32	44 x 44
25	15	18	30	40 x 36	50 x 44
26	15	20	36	40 x 36	50 x 44
27	15	20	36	40 x 36	50 x 44
28	15	20	36	40 x 40	50 x 48
29	15	20	36	40 x 40	50 x 48
30	15	20	36	40 x 40	50 x 48
31	15	20	36	44 x 44	50 x 48
32	18	24	36	44 x 44	50 x 54
33	18	24	36	44 x 44	50 x 54
34	18	24	36	44 x 44	50 x 54
35	18	24	36	44 x 44	60 x 54
36	18	24	36	44 x 44	60 x 54
37	18	24	36 x 30	50 x 44	60 x 54
38	18	24	36 x 30	50 x 44	60 x 54
39	18	24	40 x 30	50 x 44	60 x 54
40	18	24	40 x 30	50 x 44	60 x 54
41	18	24	40 x 30	50 x 44	60 x 60
42	18	24	40 x 30	50 x 44	60 x 60
43	18	24	40 x 30	50 x 48	60 x 60
44	18	24	40 x 34	50 x 48	60 x 60
45	18	24	40 x 34	50 x 48	60 x 60
46	20	27	40 x 34	50 x 48	64 x 64
47	20	27	40 x 34	50 x 54	64 x 64
48	20	27	40 x 34	50 x 54	64 x 64
49	20	27	40 x 36	50 x 54	64 x 64
50	20	27	40 x 36	50 x 54	64 x 64

Foundry Blower Practice

The air required per ton of iron melted has been variously given at from 30,000 to 33,000 cu. ft. per ton. As it is almost impossible to measure the air directly it is necessary to resort to indirect methods of chemical analysis of the escaping gases. By analyzing a sufficient number of samples, the amount of air used in the combustion of the coke can be determined with considerable exactness. The following weights and volumes of air are required per ton of iron in different melting ratios.

MELTING RATIO	AIR REQUIREMENT
Lbs. of Iron per Lb. of Coke	Cu. Ft. per Ton
7	31,000
8	29,000
9	27,000
10	25,000
11	22,000

It is customary to provide a blower on a basis of 30,000 cu. ft. of air per ton, which corresponds to from 70 to 80 per cent. of the chemical requirements with coke of average quality and a melting ratio of 7½ to 1. The pressure and quantity of air required for any particular case may be determined by means of the following formulae:

$$W = 2D\sqrt{p} \tag{44}$$

$$\text{A. P. M.} = \frac{D^2\sqrt{p}}{2} \tag{45}$$

$$\text{H. P.} = \frac{D^2\sqrt{p^3}}{3800} \tag{46}$$

where W = weight of iron in lbs. per hour.
p = press. at cupola in oz. per sq. in.
D = diam. of cupola in inches.
A. P. M. = cu. ft. of air per minute.
H. P. = horsepower required.

The above formula for A. P. M. allows for an air leakage of 10 per cent.

The table on page 110 of air per minute and H. P. for cupola service gives the cubic feet of air required per minute and horsepower of the fan for various sizes of cupola and at pressures of from 10 to 18 ounces. Knowing the size of cupola and either the pressure to be carried or the weight of metal per hour to be melted, the other factors may be readily determined from the table.

TABLE OF AIR PER MINUTE AND H. P. FOR CUPOLA SERVICE

Inside Diam. of Cupola	Static Pressure at Cupola in Oz. Per Sq. Inch					
	10 oz.	12 oz.	14 oz.	16 oz.	18 oz.	
30″	5690	6230	6730	7200	7640	CAP.
	1423	1558	1688	1800	1910	A. P. M.
	7.4	9.7	12.3	15.0	17.9	H. P.
35″	7740	8480	9170	9800	10390	CAP.
	1935	2120	2293	2450	2773	A. P. M.
	10.0	13.2	16.7	20.4	25.9	H. P.
40″	10120	11080	11970	12800	13570	CAP.
	2530	2770	2993	3200	3393	A. P. M.
	13.2	17.3	21.8	26.6	31.8	H. P.
45″	12810	14030	15150	16200	17180	CAP.
	3203	3508	3788	4050	4295	A. P. M.
	16.7	21.9	27.6	33.7	40.2	H. P.
50″	15810	17320	18700	20000	21210	CAP.
	3953	4330	4675	5000	5303	A. P. M.
	20.6	27.0	34.0	41.6	49.6	H. P.
55″	19130	20960	22640	24200	25660	CAP.
	4783	5240	5660	6050	6415	A. P. M.
	24.9	32.7	41.2	50.3	60.0	H. P.
60″	22770	24940	26940	28800	30540	CAP.
	5693	6235	6735	7200	7635	A. P. M.
	29.6	38.9	49.0	59.9	71.5	H. P.
65″	26730	29270	31620	33800	35840	CAP.
	6683	7318	7905	8450	8960	A. P. M.
	34.8	45.7	57.5	70.3	83.9	H. P.
70″	30990	33950	36670	39200	41570	CAP.
	7748	8488	9168	9800	10393	A. P. M.
	40.3	52.9	66.7	81.5	97.3	H. P.
75″	35580	38970	42090	45000	47720	CAP.
	8895	9743	10523	11250	11930	A. P. M.
	46.3	60.8	76.6	93.6	111.7	H. P.
80″	40480	44340	47890	51200	54290	CAP.
	10120	11085	11973	12800	13573	A. P. M.
	52.6	69.2	87.2	106.5	127.0	H. P.

CAP. is lbs. of metal melted per hour.
A. P. M. is cu. ft. of air required per minute.
H. P. is power required to deliver air at pressure given with steel pressure blowers.

PART III

AIR DUCTS

Under the subject of "Air Ducts," will be found detailed information pertaining to the design of various duct or conduit systems used for the conveying of air. The data relating to pressure losses and friction in piping and elbows is based on actual experiments and tests, and in many cases where required information was not to be found, special experiments were made to obtain data for use in this hand-book. The subject of the proper proportions of piping in different systems, as well as the proper velocity of air, is also completely covered.

Material of Air Ducts

One of the essential parts of any heating and ventilating system consists of the ducts or conduits used to convey the air to the desired points in the building. These ducts may go under ground, when they are usually constructed of tile, brick, or of concrete. When the system is an overhead one warm air is usually carried through galvanized iron pipes or ducts, the vertical risers being either of brick or galvanized iron. A very common construction is to run galvanized iron risers inside brick flues. In any event the inside of the duct should be made as smooth as possible, in order to avoid excessive friction and for this reason iron ducts are generally preferred to brick or concrete, unless low velocities are employed.

The piping systems for industrial buildings and those for public buildings are designed according to two distinct methods. In industrial buildings the problem is chiefly to convey heat units with as great an economy of power, material and space as possible, while in public buildings there are the additional requirements of freedom from noise and prevention of drafts. In industrial buildings air is usually conveyed through one or more main lines extending lengthwise of the building, the areas of such pipes decreasing as they extend, to give a uniform distribution of air throughout. On the other hand in public buildings individual ducts are carried from the apparatus to each room, so that it is evident the same method is not applicable to both systems.

PRESSURE REQUIRED TO OVERCOME FRICTION OF AIR PASSING THROUGH PIPES

Velocity of Air in Ft. per Min.	Loss of Pressure per 100 Feet in Inches of Water													
	Diameter of Pipe in Inches													
	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	12 in.	14 in.	16 in.	18 in.	20 in.	22 in.
200	.026	.019	.016	.012	.010	.009	.008	.007	.007	.005	.005	.003	.003	.003
300	.057	.043	.035	.029	.024	.023	.019	.017	.014	.012	.010	.010	.009	.009
400	.102	.076	.062	.050	.043	.038	.033	.031	.026	.022	.019	.017	.016	.014
500	.161	.120	.097	.080	.069	.061	.054	.049	.040	.035	.029	.027	.024	.022
600	.231	.173	.139	.116	.099	.087	.076	.069	.057	.050	.043	.038	.035	.031
700	.314	.239	.189	.158	.135	.118	.104	.094	.078	.068	.059	.052	.047	.043
800	.411	.309	.246	.206	.177	.154	.137	.123	.102	.088	.076	.069	.062	.056
900	.520	.390	.312	.260	.224	.194	.173	.156	.130	.111	.097	.087	.078	.071
1000	.642	.482	.385	.321	.276	.241	.213	.192	.160	.137	.120	.108	.097	.088
1500	1.444	1.083	.867	.723	.619	.541	.482	.434	.361	.312	.277	.243	.225	.198
2000	2.568	1.927	1.542	1.285	1.101	.964	.855	.770	.642	.550	.482	.428	.385	.350
2500	4.013	3.004	2.409	2.006	1.748	1.505	1.337	1.205	1.004	.860	.753	.669	.603	.548
3000	5.774	4.335	3.468	2.890	2.478	2.168	1.927	1.734	1.444	1.238	1.084	.964	.867	.789
3500	7.872	5.902	4.722	3.820	3.373	2.956	2.624	2.360	1.966	1.685	1.476	1.311	1.179	1.073
4000	10.276	7.706	6.166	5.138	4.405	3.853	3.425	3.083	2.568	2.202	1.926	1.713	1.542	1.401
4500	13.005	9.754	7.803	6.560	5.573	4.878	4.335	3.728	3.251	2.787	2.438	2.168	1.951	1.774
5000	16.055	12.051	9.634	8.084	6.880	5.934	5.351	4.852	4.014	3.440	3.010	2.676	2.409	2.190
5500	20.643	14.577	11.656	9.713	8.340	7.288	6.477	5.827	4.857	4.162	3.642	3.237	2.913	2.648
6000	23.120	17.340	13.871	11.561	9.908	8.670	7.706	6.936	5.780	4.985	4.335	3.853	3.468	3.152

PRESSURE REQUIRED TO OVERCOME FRICTION OF AIR PASSING THROUGH PIPES (CONTINUED)

Velocity of Air in Ft. per Min.	Loss of Pressure per 100 Feet in Inches of Water											
	Diameter of Pipe in Inches											
	24 in.	26 in.	28 in.	30 in.	.34 in.	38 in.	42 in.	46 in.	50 in.	54 in.	58 in.	62 in.
200	.00322	.00296	.00274	.00257	.00225	.00205	.00184	.00166	.00156	.00139	.00139	.00121
300	.00711	.00668	.00619	.00577	.00510	.00456	.00413	.00376	.00347	.00329	.00295	.00277
400	.01281	.01183	.01099	.01025	.00905	.00810	.00732	.00668	.00607	.00572	.00538	.00486
500	.02005	.01850	.01719	.01604	.01415	.01266	.01146	.01046	.00954	.00884	.00815	.00763
600	.02890	.02667	.02476	.02311	.02039	.01826	.01651	.01491	.01387	.01283	.01179	.01127
700	.03929	.03628	.03388	.03144	.02773	.02481	.02245	.02046	.01873	.01751	.01630	.01526
800	.05134	.04741	.04401	.04108	.03624	.03243	.02934	.02670	.02462	.02289	.02133	.01994
900	.06503	.06003	.05571	.05202	.04590	.04106	.03716	.03399	.03121	.02878	.02688	.02514
1000	.08021	.07404	.06876	.06417	.05661	.05067	.04583	.04214	.03850	.03555	.03312	.03104
1500	.18064	.16677	.15482	.14450	.12750	.11409	.10320	.09427	.08653	.08010	.07473	.06988
2000	.32105	.29638	.27271	.25451	.22460	.20092	.18182	.16732	.15417	.14270	.13282	.12415
2500	.50129	.46300	.42995	.40129	.35402	.31678	.28660	.26167	.24069	.22281	.20740	.19403
3000	.72250	.66695	.61930	.57800	.51000	.45631	.41270	.37680	.34681	.32096	.29895	.27970
3500	.98330	.90761	.84282	.78661	.69415	.62102	.56190	.51295	.47181	.43700	.40680	.38051
4000	1.2841	1.1853	1.1006	1.0274	.90650	.81111	.73381	.66985	.61575	.57066	.53131	.49696
4500	1.6257	1.5051	1.3934	1.3050	1.1476	1.0267	.92899	.84809	.78032	.72135	.67106	.62925
5000	2.0068	1.8525	1.7201	1.5986	1.4166	1.2309	1.1467	1.0462	.96337	.89178	.83022	.77666
5500	2.4284	2.2411	2.0814	1.9426	1.7140	1.5318	1.3873	1.2667	1.1654	1.0791	1.0046	.93980
6000	2.8900	2.6611	2.4771	2.3121	2.0402	1.8252	1.6473	1.5078	1.3872	1.2844	1.1947	1.1167

Pressure Losses in Air Ducts

Losses in piping systems are made up of two parts, dynamic losses and friction losses. Dynamic losses are due to changes either in direction or velocity of the air flow, and are composed of loss at entrance and loss in elbows and connections. The first is the pressure required to produce velocity in the pipe, and may vary from 1 to 1.5 times the velocity head, i. e., pressure corresponding to velocity, depending on whether the pipe is connected directly to the fan outlet or through a plenum chamber. It is expressed as a multiple of the pressure corresponding to the average velocity produced in the pipe. Where velocity in the pipe is the same as at the fan outlet this may still be considered a loss, in view of the fact that with a reduction of velocity through a gradually diverging outlet to a larger area the difference between the velocity head at the fan and the velocity head in the pipe is largely utilized by conversion to static pressure.

The other chief source of dynamic loss is in elbows, and depends on the radius of curvature of the elbow and not on its size or on the velocity of the air. This loss may be expressed directly in per cent. of velocity head, and, with a round five-piece elbow, having a center line radius of one diameter, the loss will be 25 per cent. of the average velocity head. With a five-piece elbow having a center line radius of one and one-half diameters the loss will be 17 per cent., or only two-thirds that of the first case. This shows the advantage of an intelligently designed system and the possibility in power saving, for elbows may be of so short a radius as to cause loss of an entire velocity head in each one.

The second source of pressure loss in the piping system is due to friction of air against the sides of the pipe. This loss will vary directly as the length of the pipe, or as the square of the velocity, and inversely as the diameter of the pipe. As length is a fixed quantity for any system, the only factors subject to modification are the diameter and velocity, which determine the relation between power cost and piping cost.

As in the case of heaters, it is the usual engineering practice to proportion piping arbitrarily, either from assumed velocities depending upon the velocity of the air at the fan outlet, or, in better engineering practice, by determining the velocity which will give an assumed resistance considered suitable and within the fan capacity. It is the best practice to gradually decrease the velocity in the main conduit as the latter is decreased in size owing to partial delivery of the air through the branch outlets.

This practice serves three useful purposes:

1. A proper proportioning of the velocity permits a uniform delivery of air through all the branch outlets without dampers and regardless of distance from the fan.
2. By a gradual reduction in velocity a considerable proportion of the velocity pressure is usefully converted to static pressure, thus largely compensating for piping friction.
3. It decreases friction in the smaller piping, where it would otherwise be greatest.

Friction in Air Ducts

Resistance to flow of air through piping varies with several factors such as velocity, roughness of the contact surface, or obstructions such as dampers, deflectors, and elbows. This resistance or loss in pressure is ordinarily expressed as the equivalent head in feet of air; or in velocity heads (that is the ratio of the friction loss to the theoretical pressure corresponding to the average velocity in the pipe); or as the equivalent pressure in inches or ounces. As explained on page 16 under the subject, "Relation of Velocity to Pressure," one velocity head is the pressure corresponding to the velocity of the air.

The formula used by the U. S. Navy Department for loss of head due to friction in a round pipe is

$$H = 4f\frac{L}{D}V^2 \qquad (47)$$

where H = loss of head in feet of air.

L = length and D = diameter of pipe, both expressed either in feet or in inches.

V = velocity of flow through the pipe in feet per second.

f = 0.00008 for first class piping.

Since in air measurements it is more customary to express velocity as feet per minute, this formula reduces to

$$H = 0.000000089\frac{L}{D}V^2 \qquad (48)$$

For rectangular ducts the formula becomes

$$H = 0.000000045\frac{i+n}{n}\frac{L}{i}V^2 \qquad (49)$$

where H = loss of head in feet of air.
V = velocity in feet per minute.
i = short side of pipe.
n = long side of pipe.
L = length of pipe.
f = assumed as 0.00008.

It will be noted that the loss in head as given by the above formulae is expressed in feet of air, while the head or pressure ordinarily considered in air measurements is expressed either in inches of water or in ounces per square inch. As shown by Equation (12) page 18, the velocity head expressed in feet of air is $\frac{d}{12W}$ times the head in inches of water. Taking a value of $d = 62.31$ as the density of water we then have

$$H = h'\frac{62.31}{12W}$$

$$V_0 = \frac{1096.5}{\sqrt{W}} \text{ (See page 18)}$$

where V_0 = vel. in ft. per min. corresponding to one inch of water.
W = weight of air per cubic foot.

From the above and from equation (48)

$$h' = \frac{L}{48.6D}\left(\frac{V}{V_0}\right)^2 \qquad (50)$$

where h' = loss of head or pressure.
V = velocity of air in feet per minute.
V_0 = velocity corresponding to unit pressure.
L = length and D = diameter of pipe in feet.
$\frac{L}{D}$ = length of pipe in diameters.
$\left(\frac{V}{V_0}\right)^2$ = velocity head or pressure corresponding to the velocity.

A more general form of the above equation may be expressed as

$$h' = \frac{L}{CD}\left(\frac{V}{V_0}\right)^2 \qquad (51)$$

where C = a constant depending on the character of the pipe.

The constant C in the above formula represents the length of pipe in diameters causing a loss of one velocity head. For perfectly smooth unobstructed pipe we may take C=60, but for fairly smooth work such as the piping of a planing-mill exhaust system a safe factor would be C=55. For heating and ventilating work where there exist more or less obstructions in the form of dampers, deflectors, etc., and where the piping is usually swedged, we may consider one velocity head lost in from 45 to 50 diameters. For such systems we may usually take C=45. For tile or brick ducts C=40 will meet the average conditions.

From the above we see that if the velocity in a 12-inch pipe is 2832 feet per minute (corresponding to ½ inch) and the pipe is 45 feet long, the loss in pressure will be one velocity head, or ½ inch. If, for instance, a pressure of ½ inch is required at the outlet end of the pipe, a pressure of 1 inch must be maintained at the entering end.

Friction in rectangular pipe may be determined by using the tables on pages 156 and 157 which give the circular equivalent of rectangular pipes computed to give equal friction for the same air quantities. By means of this table the corresponding diameter of round pipe may be found, and the friction loss determined as above.

Friction in Elbows

The two diagrams on pages 118 and 119 of pressure loss in elbows show respectively the loss by friction through elbows of either round or square section. These curves are based on data obtained at the testing plant of the Buffalo Forge Company, full details of the tests and of the results obtained being described in a paper presented before the A. S. H. & V. E. on "Loss of Pressure due to Elbows in the Transmission of Air through Pipes or Ducts."* The loss in per cent. of a velocity head is given for elbows of different radii, the center line radius being expressed in per cent. of the pipe diameter or width.

It may be seen from these diagrams that with R=1½D, or an inside throat radius of one diameter, fairly good results may be obtained without making the elbow unduly long. Practically nothing is to be gained by making R greater than 2D.

It is also evident from an inspection of these diagrams that if it can possibly be avoided an elbow with R less than one D should not be used. Even with these an elbow in a square duct will cause a loss of 17.5 per cent. and in a round duct 25.5 per

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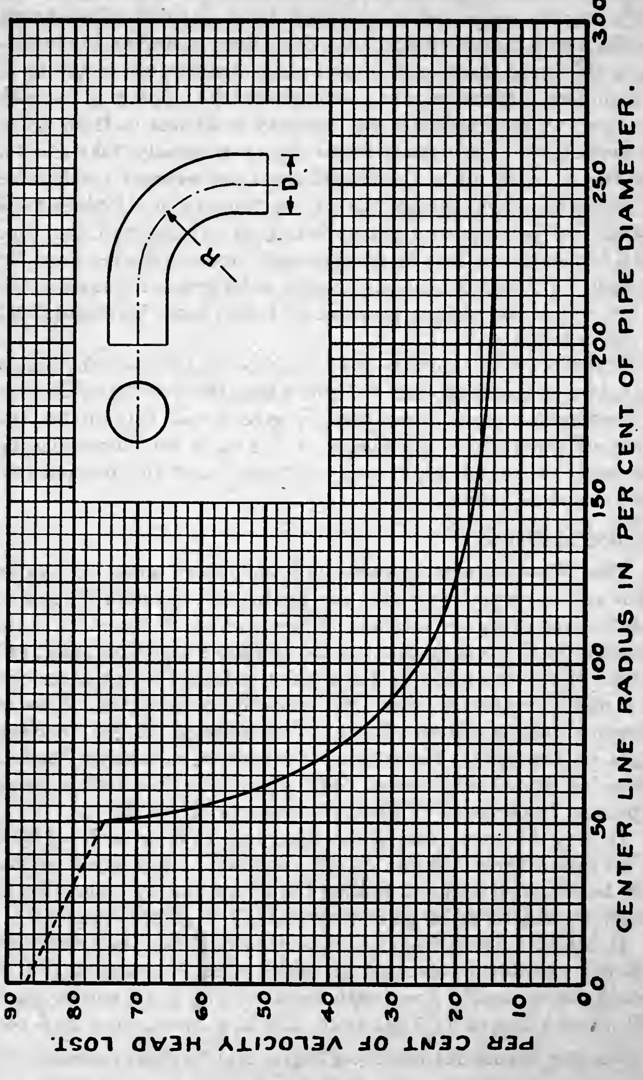
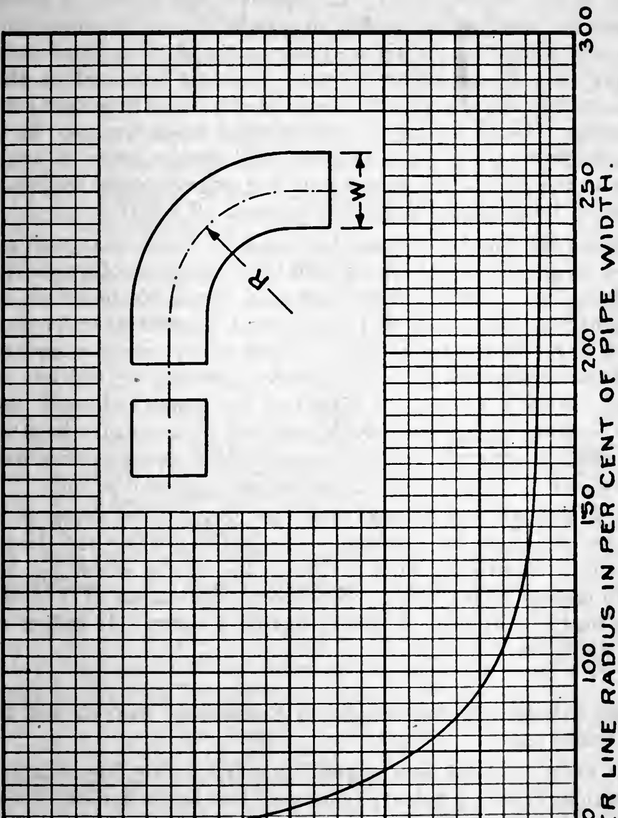
*Am. Soc. Heating and Ventilating Engrs., 1913, by Frank L. Busey.



Loss of Pressure in Round Elbows



Loss of Pressure in Square Elbows

Powdered Coal Engineering & Equipment Co.

cent. of the velocity head. In case R = ½D (throat of elbow square but outer side rounded to a radius of one diameter) the loss will be 95 per cent. for a square duct and for a round duct 75 per cent. of the velocity head. The loss indicated on the diagram for R = D represents tests on elbows of two-piece construction, or with both inside and outside made square. It is evident that this is a construction that should never be used, since in the case of the square pipe one quarter of the loss may be saved by making the outer side round (R = ½D).

From the curve for round ducts it will be seen that with an elbow having R = 1½D the loss will be 17 per cent. of a velocity head. If we consider one velocity head lost in 50 diameters of straight pipe this means that this elbow is equivalent in friction effect to 8.5 diameters of pipe. If the elbow was in a square duct the loss would be equal to 4.5 diameters (or widths) of pipe. With a velocity of 4000 feet per minute through the duct (corresponding to one inch pressure, or a velocity head of one inch) the above elbow in the round pipe would cause a loss in pressure of 0.17 inch and in the square duct of 0.09 inch.

For ordinary calculations one easy long radius elbow in a circular pipe may be considered as equal in friction loss to 10 diameters of straight pipe. This is the factor given by N. S. Thompson in his book, "Mechanical Equipment of Federal Buildings," as applied to elbows having a center line radius of 1½ diameters.

Pressure Losses in Diverging and Converging Nozzles and in Orifices

It may be stated as a general principle in air flow calculations that "The coefficient of pressure loss is the square of the reciprocal of the coefficient of discharge," i. e., the coefficient of pressure loss, **m**, in terms of the coefficient of discharge, **c**, may be stated as

$$m = \left(\frac{1}{c}\right)^2 \tag{52}$$

and the loss in static pressure will be

$$p_s = m\left(\frac{V}{V_0}\right)^2 \tag{53}$$

where V = velocity of air flow and V_o = velocity corresponding to unit pressure. Then $\left(\frac{V}{V_0}\right)^2$ will be the velocity pressure.

Coefficients of discharge to be used in air measurements will be found below. Coefficients for pressure loss will be

m for sharp edged orifice	2.78
m for short length (2½ to 3 diam.) of pipe	1.47
m for short pipe on fan outlet	1.11

The coefficient m for converging nozzles having different angles of convergence between the two sides will be

Angle of Convergence	Coefficient m
6 degrees	1.175
8	1.150
10	1.140
12	1.130
14	1.130
22.5	1.185

In case any of the above factors are to be considered, there will be a loss in static pressure—and the same loss in total pressure—of m times the pressure due to the velocity.

When a diverging nozzle is to be considered, as shown by the diagram on page 123, there will be a certain gain in static pressure as determined by the coefficient e.

The coefficient of loss m will then be (1−e), but in this case the coefficient m is to be applied to the change in velocity head due to the nozzle, and is a measure of the loss in total pressure. That is, the gain in static pressure will be

$$p_s = e\left[\left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2\right] \qquad (54)$$

The loss in total pressure will be

$$p_t = (1-e)\left[\left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2\right] \qquad (55)$$

In the above formulae the change in velocity head between the entering and leaving end of the nozzle is expressed by

$$\left[\left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2\right]$$

V_1 = velocity of air entering nozzle.
V_2 = velocity of air leaving nozzle.
V_0 = velocity corresponding to unit pressure.
e = coefficient from diagram on page 123.

Diverging Nozzle in Air Ducts

A diverging nozzle is used in an air duct when the area is increased in order to reduce the velocity, or when blowing into an enclosed space or plenum chamber. Any change from a higher to a lower velocity is accompanied by a conversion from velocity to static pressure, but inasmuch as there is always some loss in making this conversion, the total pressure is not the same after making the reduction in velocity. That is, there is always a certain portion of this converted static pressure lost in making the change, and the efficiency of conversion is never the full 100 per cent. As will be seen from the chart on page 123, the efficiency of conversion depends on the per cent. of slope of the sides of the diverging nozzle, the more gradual the slope the less the loss in pressure.

The diagram on page 123 shows the efficiency, or ratio of actual to theoretical velocity head obtained with diverging nozzles of different slopes to the sides. That is, while theoretically we should obtain an increase in static pressure equal to decrease in velocity pressure we will really convert only a part of this decreasing velocity pressure to static pressure, depending on the slope of the nozzle. While theoretically we should have

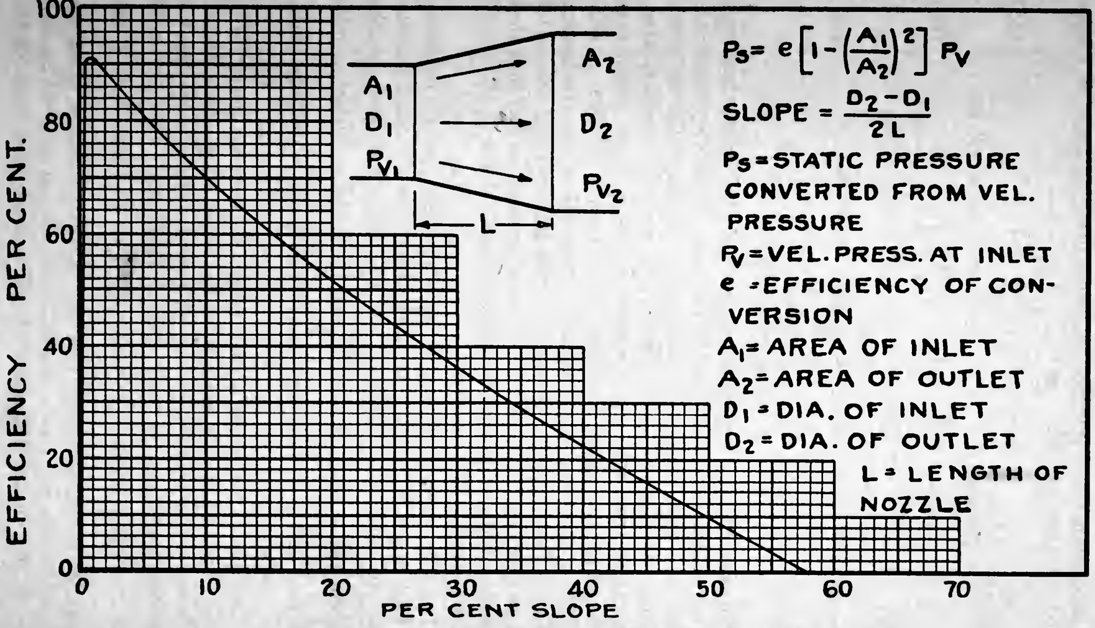
$$p_{s2} - p_{s1} = p_{v1} - p_{v2} = \left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2 \qquad (56)$$

as a matter of fact we will have

$$p_{s2} - p_{s1} = e\left[\left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2\right] \qquad (57)$$

where e represents a factor depending on the proportions of the nozzle.

For instance, if we have a nozzle whose length is five times half the difference between the diameters of the two ends, that is a length of five times the slope or a slope of 0.20, we will have an efficiency of conversion of 51.5 per cent. In case the side of a nozzle makes an angle of say 30 degrees, the slope will be 0.577 and we may see from the curve that there will be no gain from the cone outlet. From the foregoing it may be seen that length of a diverging nozzle should be made as long as the case will permit in order to get the greatest possible benefit from it. The length should be at least from five to ten times the slope, giving a slope of from 0.10 to 0.20 or an angle of approximately 6 to 12 degrees.



EFFICIENCY OF DIVERGING NOZZLES.

Conversion from velocity to static pressure may be determined from the formula

$$p_s = e\left[1 - \left(\frac{A_1}{A_2}\right)^2\right]p_v \qquad (58)$$

and loss in pressure due to the increase in area will be

$$p_t = (1 - e)\left[1 - \left(\frac{A_1}{A_2}\right)^2\right]p_v \qquad (59)$$

where p_s = static press. converted from vel. press.

p_t = loss in total press.

p_v = velocity press. at inlet of nozzle.

e = efficiency of conversion.

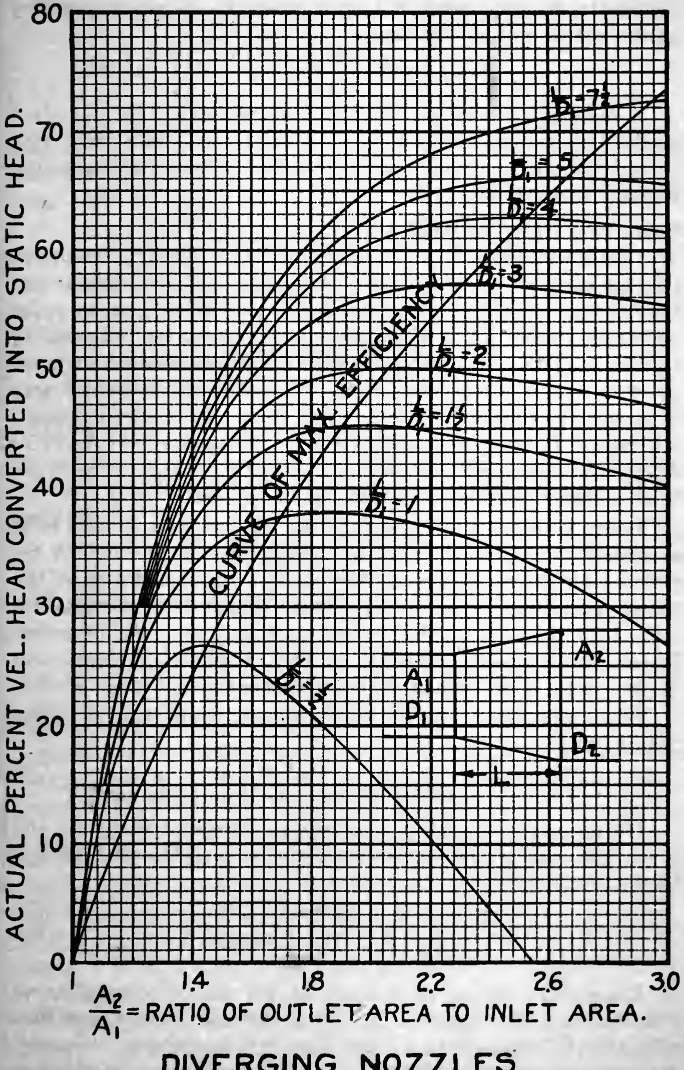
A_1 = area of inlet to nozzle.

A_2 = area of outlet from nozzle.

On page 125 will be found a diagram plotted from actual tests of diverging nozzles, showing the per cent. of velocity head converted into static head by using nozzles having different ratios of length to diameter of outlet, as well as outlet to inlet area. While these tests were made with round pipe, it was found that the same relations held for those of rectangular section. As an example of the use of the diagram we may select a nozzle having a length equal to twice the small or inlet diameter and the outlet area twice the inlet area. From the diagrams we will find that a nozzle of these dimensions will convert 50 per cent. of the velocity head into static head.

The line marked "Curve of Maximum Efficiency" indicates the best ratios of outlet to inlet areas for different fixed lengths of nozzle and inlet diameter. It will be noted that for the different ratios of $\frac{L}{D_1}$ there is a certain ratio of outlet to inlet area that will give maximum conversion from velocity to static pressure.

Example. Assuming a case where a diverging nozzle is to be used on a 24-inch pipe in order to increase the diameter and so decrease the velocity in the pipe, and owing to the limited space the nozzle can be made only six feet long. Then the ratio $\frac{L}{D_1} = 3$, and according to the diagram we will obtain the maximum conversion from velocity to static pressure when the area of the enlarged pipe is made 2.3 times the area of the 24-inch pipe, or 36.5 inches diameter. In this case 57 per cent. of the



DIVERGING NOZZLES.

change in velocity head will be converted into static pressure at the nozzle outlet. Then

$$p_{s2} - p_{s1} = 0.57\left[\left(\frac{V_1}{V_0}\right)^2 - \left(\frac{V_2}{V_0}\right)^2\right]$$

A diverging nozzle on the outlet of multivane fans is often used to advantage, giving a reduction of the comparatively high velocity at the outlet of this type of fan, with a corresponding increase in static pressure.

Theoretical Outlet or Blast Area

It is a well known fact that air (or water) under pressure in passing through an orifice in a thin plate will not deliver the volume indicated by the actual area of the orifice, because the resistance of the orifice, depending on its character, will tend to restrict the flow. It follows then that there will in each instance exist an equivalent or blast area, differing from the actual area in proportion to the resistance. **This blast area of an air conveying system is the area which would be theoretically required to deliver the same amount of air at a velocity corresponding to the total pressure resistance offered by the system.**

Every point in a fan blast system has its blast area, which, as stated above, is less than the actual area by an amount depending on the resistance at that point. The blast area of the entire system may then be computed, inasmuch as the total resistance is the sum of the various resistances passed in series. In case the air passes through parallel channels the blast area of the system is the sum of the blast area of the separate channels.

Blast area based on the total pressure drop may be determined from

$$\text{Blast area} = \frac{\text{A. P. M.}}{4005\sqrt{\text{total press. drop in inches}}} \qquad (60)$$

Representing the blast area of an entire system by A_b and the blast area of the various sections by A_{b1}, A_{b2}, etc., we will have the relation

$$A_b = \frac{1}{\left(\frac{1}{A_{b1}}\right)^2 + \left(\frac{1}{A_{b2}}\right)^2 + \text{etc.}} \qquad (61)$$

Examples. As an illustration of the above principles, we will assume a case where a fan blows through a short pipe into a heater and thence into a single duct piping system. We may determine the drop in static pressure for the various sections of the system, and calculate the blast area of each by means of the formula

$$\text{Blast area} = \text{actual area}\sqrt{\frac{1}{\text{static loss in vel. heads} + 1}}$$

Assuming the connection between fan and heater to have an area of 4.9 sq. ft. with a loss of entrance of 0.1 vel. head and 0.25 vel. head lost in the connection itself, we find the blast area of this section to be

$$A_{b1} = 4.9\sqrt{\frac{1}{0.35 + 1.0}} = 4.24 \text{ sq. ft.}$$

The blast area of the heater may be found by means of the above general formula. With 10000 A. P. M. and a pressure drop of 0.5 inches through the heater, the blast area will be

$$A_{b2} = \frac{10000}{4005\sqrt{0.5}} = 3.53 \text{ sq. ft.}$$

If we assume 0.5 velocity head lost by entrance to the piping system, and two velocity heads lost in the ducts and elbows, we will have as the blast area of this part of the system, if the main pipe is 35 inches in diameter

$$A_{b3} = 6.68\sqrt{\frac{1}{2.5 + 1.0}} = 3.58 \text{ sq. ft.}$$

The blast area of the entire system may then be found from

$$A_b = \frac{1}{\left(\frac{1}{4.24}\right)^2 + \left(\frac{1}{3.53}\right)^2 + \left(\frac{1}{3.58}\right)^2} = 4.68 \text{ sq. ft.}$$

Proportioning the Various Losses

In addition to loss of pressure due to friction in piping and elbows, there is a loss of static pressure due to entrance to the piping system of from 0.1 to 0.5 of a velocity head. In addition to this, one velocity head must be maintained to produce the required velocity in the system. In case the piping is connected directly to the fan outlet this loss of entrance is frequently neglected especially if the piping is larger than the fan outlet and is made cone shaped. This is the case in a draw-through system, where the fan draws the air through the heater and blows directly into the piping or ducts. Where the system is a blow-through one, that is, the fan blows into the heater and the air passes through and into the ducts, a considerable loss will occur at the entrance to the piping system, depending on the character of the layout. Where the piping is connected to the heater casing by an easy cone shaped approach, the loss of static pressure may be only 0.2 or 0.3 of a velocity head. In case the fan blows through the heater and into a plenum chamber, from which the pipes radiate to different parts of the building, the loss of entrance to these pipes may be as much as 0.5 of a velocity head. In any case the pressure required at the fan must be one velocity head greater in order to produce the velocity desired in the piping.

It is evident from the above that loss of power due to friction is less in a draw-through than in a blow-through system. Loss of pressure through the heater would be the same in either case, and may be determined from the table on page 446.

In the case of the draw-through system, the sum of all the pressure losses is to be deducted from the total pressure at which the fan is operating, while with the blow-through apparatus this loss is to be deducted from the static pressure.

In an ordinary draw-through system it is usually considered advisable to keep the sum of all piping losses approximately one-third to one-half, and the loss through the heater at less than one-half of the total pressure. The balance is then available for producing velocity. In case a system has been laid out and the pressure loss is found to be greater than desired, the size of the piping may be reproportioned by means of the following formula so as to obtain the desired pressure drop.

$$C_2 = C_1\sqrt{\frac{p_2}{p_1}} \qquad (62)$$

where C_1 = present pipe area.
C_2 = required pipe area.
p_1 = present pressure loss.
p_2 = desired pressure loss.

Thus, if we have made a layout for a system which it is desired to operate at a total pressure of not more than one and one-half inches, and find that at the velocity required to handle the air through the sizes of ducts selected the piping loss will be say one inch, we may reproportion the size of the ducts by the above formula. Assuming that a maximum pressure loss of 0.75 inch is to be allowed instead of the above 1.00 inch, we have

$$C_2 = C_1\sqrt{\frac{1.00}{0.75}} = 1.15\,C_1$$

That is, the area of all the ducts in the system must be increased 15 per cent., or the diameters increased 7 per cent. Then if the heater loss is found to be 0.60 inch, and the velocity through the main duct is to be 1800 feet per minute, corresponding approximately to 0.2 inch, the total pressure required at the fan will be 1.55 inches.

Proportioning Piping for Exhaust Systems

It is recommended in the design of piping for an exhaust system where no dampers are provided, to make the area of the main pipe approximately 20 per cent. greater than the sum of the area of the branch pipes at that point. This results in greater uniformity of distribution than where the increase in area is not made.

Where dampers are provided, as in the vent system from buildings, uniform velocity through the system should be maintained by making the area of the main duct equal the area of the branches. Where the exhaust ducts in a public building connect directly to the exhaust fan, a velocity of from 1200 to 1500 feet per minute may be allowed in both branches and main. Where the exhaust register or opening is placed near the floor, a velocity of from 600 to 750 feet per minute should be allowed in the register box. Velocity of the air should be kept uniform throughout the entire system.

For public buildings where a plenum exhaust system (vent stacks connecting into one large chamber, such as an attic) is used and the air discharged from this chamber by means of an exhaust fan, it is customary to allow a velocity of 600 to 750 feet per minute through the vent stacks and remove the same amount of air delivered by the supply fan. When the air is discharged from the exhaust chamber by some other means than an exhaust fan, about two-thirds the amount of air supplied to the building is ordinarily taken as a measure of the air discharged, with a velocity in the exhaust stacks of from 400 to 500 feet per minute. In either case this makes the exhaust or vent stacks the same area as the supply risers.

For industrial buildings, a velocity of from 1500 to 2000 feet per minute may be allowed through the exhaust system, the velocity being made uniform in both the mains and branches. The actual velocities assumed in any case will depend on the best proportion between the first cost and the operating cost. A study of the relation between these two factors will be found on page 130.

The design of the piping system as well as the size of branch pipes required for a refuse exhaust system will be found discussed under "Exhaust Systems," Part II, Section V.

Proportioning Piping for Maximum Economy

The subject of the most economical velocity of air through piping systems has been discussed in a paper* presented before the A. S. H. & V. E. at their 1913 annual meeting, some of the more interesting conclusions of which will be here given.

A decrease in velocity increases the size and cost of the air conduit, but decreases cost of power consumed in overcoming the conduit or piping resistance. From a point of economy the question to be determined is what relation between power cost and conduit cost, as determined by the velocity, will give minimum annual total cost.

This relationship may be shown to be

$$\left(\frac{V_m}{V_o}\right)^3 = 0.335\left(\frac{C_{wo}}{C_{po}}\right) \qquad (63)$$

or

$$V_m = 0.7\ V_o\left(\frac{C_{wo}}{C_{po}}\right)^{1/3} \qquad (64)$$

Where C_{po} and C_{wo} represent respectively cost of power to overcome piping resistance and an annual charge for interest and depreciation on piping designed for an assumed velocity V_o; and V_m is the relative velocity required for maximum economy.

Comparing these relationships with those obtained for the heater on page 414, it is evident that they are almost identical. It will be seen in this case that for maximum economy the annual cost of power consumed by piping resistance should be practically one-third of the annual interest and depreciation charges based on initial cost of piping. That is $C_p = 0.335\ C_w$ for maximum economy. This annual allowance on the piping system for interest and depreciation may be assumed to be about 25 per cent. of the original cost of the installation.

While these lower velocities and consequently lower resistance would require the use of large fans in order to operate at high efficiency, considering the entire installation of heater, piping and fan, the annual cost of power should be practically

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*"The design of Indirect Heating Systems with Respect to Maximum Economy of Maintenance and Operation," by Frank L. Busey and Willis H Carrier.

30 per cent. of the total annual allowance for interest and depreciation. If this allowance is taken at 20 per cent. as an average, we would have approximately 6 per cent. on the first cost as the most economical yearly rate to be allowed for power.

Practical Applications

For the purpose of illustrating the application of the foregoing principles to a system of galvanized iron piping, different cases will be assumed and results shown. A system handling 30000 cu. ft. per minute, at a velocity of 1950 ft. per minute, will require a pipe 53 inches in diameter, or an area of 15.32 sq. ft. These quantities will be taken as a constant condition, but different arrangements considered in the system of piping.

Assuming one straight duct 200 feet long and 53 inches in diameter, delivering all of the air at the end farthest from the fan, we will have two sources of loss to be overcome by the fan.

First, the dynamic loss due to the velocity of 1950 feet per minute (or one velocity head), and second, the loss due to friction, amounting to one velocity head in each 50 diameters of length. The pressure due to the velocity of 1950 feet per minute in the pipe (one velocity) will be 0.237 inch, water gauge. The loss of pressure due to friction will be

$$\frac{200}{4.42 \times 50} = 0.905 \text{ velocity head}$$

This loss expressed in inches of water will be

$$0.237 \times 0.905 = 0.214 \text{ inch}$$

and the total loss will be the sum of these two, or 0.451 inch. In the piping system a part of the velocity is converted to static pressure, hence the power calculated should be based on total pressure with a corresponding fan efficiency of 50 per cent. At a rate of $20 per H. P. yr., the annual cost due to the piping resistance will be

$$C_{po} = 30000 \times 0.000324 \times 0.451 \times 20 = \$48.$$

A round galvanized iron pipe, 53 inches in diameter, would be made of No. 18 iron, weighing 2.3 pounds per square foot, and would contain 14.2 sq. ft. per running foot. This would make 32.7 pounds per running foot, or a total of 6540 pounds for the entire pipe. Allowing 25 per cent. annually for interest and depreciation on an initial cost of say 10 cents per pound, the yearly allowance would be 2.5 cents per pound of iron. Then we would have as the yearly allowance for interest and depreciation

$$C_{wo}=6540\times 0.025=\$163.50.$$

From equation (64) we may determine that for the most economical conditions the velocity of air in the pipe should be

$$V_m=0.7\times 1950\left(\frac{163.5}{88.0}\right)^{1/3}=1670 \text{ ft. per min.}$$

Assuming the case where 30000 cu. ft. per minute is to be uniformly distributed by a galvanized iron pipe 200 feet long, with equal openings every 20 feet of its length, each discharging 3000 cu. ft. per minute, we will have an example of another common form of installation. Referring to the chart, page 138, we see that, if the first 20 feet of pipe is 53 inches in diameter, the next 20 feet carrying 90 per cent. of the air should be 51 inches in diameter. Treating each successive section in the same manner we may determine the diameter and weight of each section, and will find the total weight of the piping to be 3922 pounds. Then the yearly total allowance for interest and depreciation on the piping system will be

$$C_{wo}=3922\times 0.025=\$98.05$$

Loss in pressure due to friction will be the same as in the first case considered, or 0.214 inch, but loss due to velocity will be only 40 per cent. of the loss as calculated in the first example, or 0.095 inch. The total pressure loss will then be

$$0.214+0.095=0.309 \text{ inch.}$$

and the annual power cost at \$20 per H. P. yr. will be

$$C_{po}=30000\times 0.000324\times 0.309\times 20=\$60.$$

As before from equation (64) we will have as the velocity for the most economical operation

$$V_m=0.7\times 1950\left(\frac{98.05}{60.00}\right)^{1/3}=1575 \text{ ft. per min.}$$

Proportioning Ducts for Public Buildings

In public buildings the sizes of air-conveying ducts from fans or heaters to vertical induction flues, and the sizes of these flues, depend upon the velocity of flow in such ducts and flues. The essential factors in determining these velocities are: Limitations of economical relative speed of fans from the standpoint of power; limitations of air velocities on account of noise or by reason of increasing friction as velocities increase; limitations of velocity of inflowing air through registers into rooms; desirability of as high a velocity of air as is permissible under the limitations referred to in order to get as quick a conveyance of the warmed air as possible; and necessary initial and intermediate velocities to overcome the resistance existing in each particular system or case.

Register Velocity

The size of vertical flues to the registers in the rooms is determined by the maximum velocities allowable in avoiding drafts and noise in the rooms. Practice has shown that the best velocities for the registers should be from 200 to 400 feet per minute over the face of the register, depending upon the size and location; floor registers from 125 to 175 feet. Velocity in the vertical flues leading to the registers should be from 400 to 750. Sizes of these vertical flues are determined largely by the size of register desirable. In general, the velocity in these risers should be low, in order to obtain as uniform a flow as possible over the register area.

STANDARD SIZES OF REGISTERS AND RISERS FOR PUBLIC BUILDINGS

Cu. Ft. of Air per Min.	Register Size Inches	Av. Vel. Over Face of Reg.	Size of Riser Inches	Riser Velocity Ft. per Min.
160	8 x 13	220	6 x 8	490
230	8 x 18	230	8 x 8	510
290	10 x 18	230	8 x 10	525
360	12 x 18	240	8 x 12	540
430	14 x 18	245	8 x 14	555
510	16 x 18	255	8 x 16	570
580	12 x 30	230	12 x 12	580
690	14 x 24	295	12 x 14	590
810	16 x 28	260	12 x 16	605
925	18 x 27	275	12 x 18	615
1040	20 x 26	290	12 x 20	625
1160	22 x 28	270	12 x 22	635
1290	24 x 27	285	12 x 24	645
1450	20 x 36	290	16 x 20	653
1620	22 x 36	295	16 x 22	663
1790	24 x 36	300	16 x 24	672
1970	24 x 36	330	16 x 26	680
2140	27 x 38	300	16 x 28	687
2310	30 x 36	310	16 x 30	693
2490	30 x 36	330	16 x 32	700

Duct Velocity

The velocity in horizontal ducts leading from the apparatus to the vertical risers is determined chiefly by the resistance of the duct. In practice these velocities will vary from 700 feet to 1200 feet depending upon size and length of duct, number of elbows, etc. A designer with considerable experience may proportion these ducts so as to give very uniform distribution without going into any extended calculation. However, it is desirable to have a correct method as a basis. For the benefit of engineers and architects we give here the method that may be employed in the determination of duct velocities and sizes.

Allowing for Friction

The principal losses in piping systems for public buildings are in the horizontal ducts where velocity is highest. Losses in these ducts depend upon velocity, size and length of duct, and upon the number of elbows, together with a considerable loss in pressure as the air enters the duct. An ideal system should take all these factors into consideration and so proportion the velocities that the resistance may be practically equal in all ducts regardless of the length, etc. The system above mentioned accomplishes this in a practical manner and at the same time avoids any laborious calculation. For each duct a factor may be obtained by inspection in accordance with the following formula:

$$F = 2\tfrac{1}{2} + \frac{L}{4W} + \frac{N}{5} \qquad (65)$$

This factor represents loss by friction in terms of velocity head. The first term, 2½, is approximately the number of times the velocity head is lost by entrance to the pipe, entrance to the vertical flue, and loss in riser and register. The second factor represents loss due to length and size of pipe; L is length in feet and W is approximate width in inches. The third term represents that proportion of the pressure lost in elbows, and N is the number of long radius elbows. One square elbow is considered equal to two long radius elbows. In checking over the piping layout the factors for the various ducts are first found as above and from these factors the velocity in the respective ducts is ascertained directly. In determining these velocities it is usual to allow a loss not exceeding one-quarter of the total fan pressure, which in practice usually amounts to about one-quarter of an inch. The velocity corresponding to a pressure of one-quarter of an inch is 2000, and since the velocities vary as the square root of the pressures, the factor F and the velocity V will give a loss of one-quarter of an inch if

$$V = \frac{2000}{\sqrt{F}} \qquad (66)$$

Example. As an example of the above system we will assume a case where the longest run of pipe L = 50 feet, W = 18 inches, and the number of easy elbows N = 4

We will then have

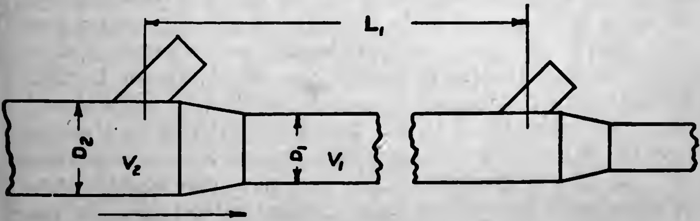
$$F = 2.5 + \frac{50}{72} + \frac{4}{5} = 4.0 \text{ velocity heads}$$

Velocity which will cause a loss of one-quarter inch will then be

$$V = \frac{2000}{\sqrt{4}} = 1000 \text{ ft. per min.}$$

Proportioning Piping for Industrial Buildings—Supply or Blast System

In proportioning main and branch pipes in industrial buildings, the primary aim is to secure as uniform a distribution as possible without the necessity of dampering, as well as to secure economy of power and economy of material. It has been found good practice in proportioning piping systems to decrease the velocity in the main pipes as the air quantity decreases. As already stated, this principle of proportioning has three advantages. First: It utilizes the velocity of the air in producing static pressure in the system. Second: By this means a nearly uniform static pressure may be secured in all parts of the pipe line, giving a very uniform distribution of air throughout. Third: It reduces the friction in the smaller pipes, which would otherwise be excessive.



Equations giving ideal distribution of static pressure for round pipes are

$$\frac{V_2}{V_1}=\sqrt{\frac{L_1}{40D_1}+\frac{N}{5}+1} \qquad (67)$$

and

$$\frac{D_1}{D_2}=\sqrt{\frac{C_1}{C_2}}\sqrt[4]{\frac{L_1}{40D_1}+\frac{N}{5}+1} \qquad (68)$$

These equations for rectangular pipes are

$$\frac{V_2}{V_1}=\sqrt{\frac{(a+b)L_1}{80\,a\,b}+\frac{N}{5}+1} \qquad (69)$$

or when the short side a remains constant and the long side b changes

$$\frac{b_2}{b_1}=\frac{C_2}{C_1}\frac{1}{\sqrt{\frac{(a+b)\,L_1}{80\,a\,b}+\frac{N}{5}+1}} \qquad (70)$$

where V_1 = an assumed or predetermined velocity in a length of pipe.

V_2 = velocity in the preceding length of pipe.

L_1 = length and D_1 = diameter both expressed in feet of the length of pipe having the velocity V_1.

N = number of easy long radius elbows in section L_1.

C_1 and C_2 = the corresponding air quantities in the pipes D_1 and D_2.

a = short side and b = long side of a rectangular pipe.

The application of these formulae is clearly shown by a reference to the sketch on page 135, where velocity V_1 is known and velocity V_2 is to be determined. The decrease in velocity between V_2 and V_1 will then be sufficient to care for the static losses of the section having the velocity V_1.

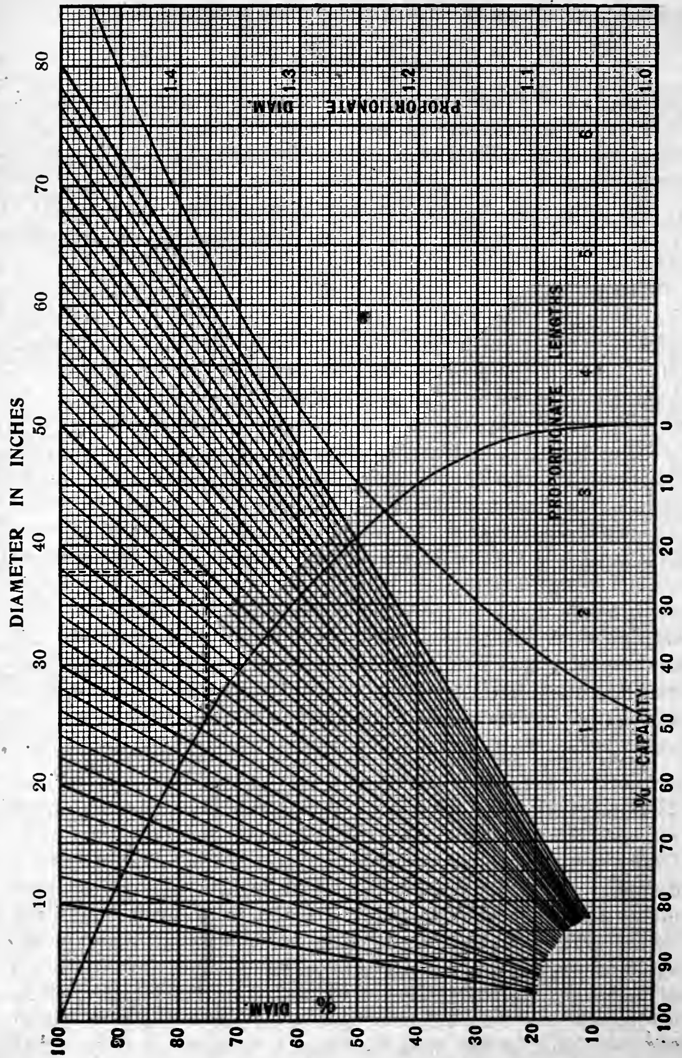
The following method of proportioning piping has been carefully tested and has been found to give a satisfactory distribution when applied to the reduction in size of the main duct with a series of outlets along its length, or to branch pipes of equal length. It also facilitates the calculation of friction. When the branch pipes are of unequal length a correction should be applied as explained under "Equalizing Friction for Unequal Length" on page 139. The principle involved is to so proportion the velocities in the various pipe sizes as to give equal friction in all air pipes per running foot regardless of their size. It may easily be shown that the equation which relates the carrying capacity of a pipe to its size to suit this condition is

$$\frac{d_2}{d_1} = \left(\frac{C_2}{C^1}\right)^{2/5} \tag{71}$$

Where d_1 and d_2 are the relative diameters of two pipes and C_1 and C_2 are the relative air quantities. As an equation in this form would be difficult of computation, the diagram shown on page 138 may be conveniently employed.

In using this chart commence with the main pipe equal in area to the fan outlet, or larger, as circumstances may require. All sizes are proportioned directly from this main pipe size. It will be noted that the curve is plotted for per cent. capacity and for per cent. diameter according to the formula for constant friction per foot of length. For instance, if we have a branch pipe which is required to carry 50 per cent. of the capacity of the main pipe, we find the point on the curve which corresponds to 50 per cent. capacity and which gives a corresponding point of 76 per cent. diameter; that is, a pipe to carry 50 per cent. of the capacity with the same friction per foot must have 76 per cent. of the diameter, which may be easily calculated or be read directly from the chart for various pipe sizes. It will be seen that straight lines are drawn for pipe sizes from 20 inches up to 80 inches in diameter. Supposing the size of the main pipe is 60 inches in diameter, then following to the line of 60-inch pipe, we find from the scale above a diameter of 46 inches, which is the size of pipe which has half the capacity of a 60-inch pipe with the same friction per foot. By this method the sizes may be read off rapidly without any intermediate calculation.

Example. Let the main pipe from the fan be 48 inches in diameter in the form of a straight duct having ten equal outlets. The first section of piping is 48 inches, the second section has a capacity of 90 per cent., the third section 80 per cent., the fourth 70 per cent. and so on. Corresponding to 90 per cent. we find a diameter of 96 per cent. which for a 48-inch pipe gives us 46 inches for the second section. For the third section we have 80 per cent. capacity corresponding to 91 per cent. diameter, or again following from left to right to the 48-inch line, we find a diameter of approximately 44 inches. For the fourth section we have 70 per cent. capacity with a corresponding pipe size of 86½ per cent. of the main pipe and a diameter of between 41



Proportioning Piping to Allow for Friction inches and 42 inches determined as before. For the last section we have 10 per cent. capacity or 40 per cent. diameter, which gives a diameter of between 19 inches and 20 inches.

The sizes of the outlets are not calculated by means of this diagram, but are proportioned so as to give the desired velocity to the air leaving the outlets. This velocity will be determined by the size of the room and consequent distance the air is to be carried, and by the required freedom from drafts due to high velocity of the air leaving the outlets. Outlet velocities varying from 500 to 1400 feet per minute are ordinarily used, depending on the circumstances. The most commonly used velocity at the outlet is about 1000 feet per minute.

As already stated, the above system of proportioning piping applies to the reduction in size of the main pipe where a series of outlets are taken off, or to branch pipes of equal length. When these branch pipes are of unequal length, a correction should be applied as explained in the next paragraph under "Equalizing Friction for Unequal Length."

Equalizing Friction for Unequal Length

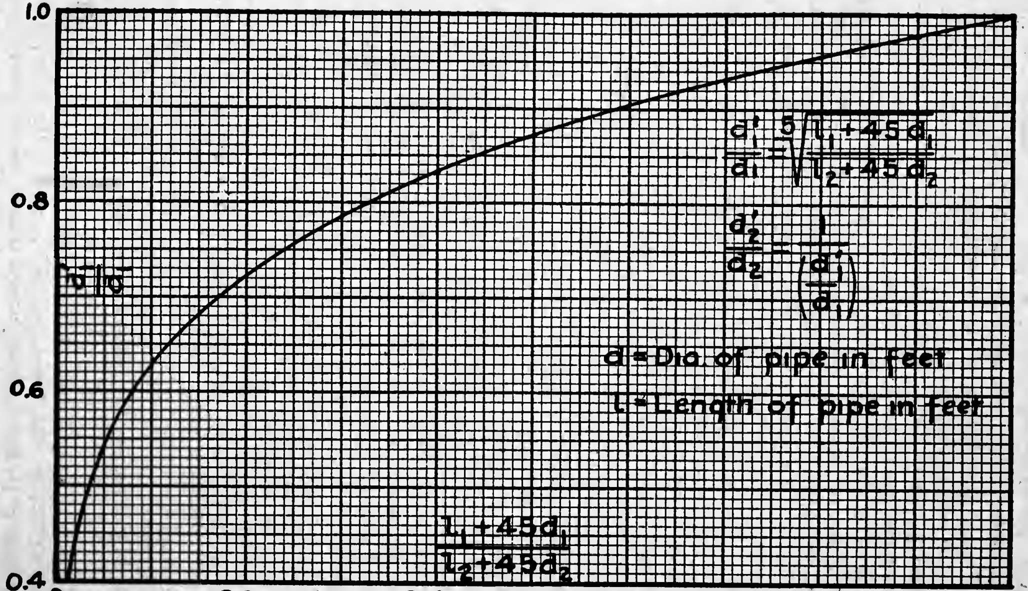
The above system of proportioning piping refers to cases where outlets or branch pipes are of equal length. In case one or more of these branch pipes are of unequal length the shorter pipes will tend to discharge more air than intended. It will then be necessary to so design the various branches that the frictional resistance in each will be equal, or adopt the common practice of placing a damper in each pipe and partly closing it in the pipes which deliver too much air.

The better way of equalizing the friction through a system having runs of unequal length is so to proportion the different runs that the resistance of each is the same. This may be accomplished either by using a smaller pipe and higher velocity in the short pipes, or by making the long run of greater diameter with a corresponding lower velocity and pressure loss.

The change in diameter required to accomplish this equalization of friction loss due to unequal lengths of piping may be computed by means of the following formula,

$$\frac{d_1'}{d_1} = \sqrt[5]{\frac{l_1 + 45\,d_1}{l_2 + 45\,d_2}} \qquad (72)$$

where d_1 and d_2 are the diameters, and l_1 and l_2 the lengths of the two runs of piping, both expressed in feet, as originally laid out, and d_1' is the diameter d_1, corrected so as to equalize friction



EQUALIZING FRICTION FOR UNEQUAL LENGTH OF PIPES.

between the two branches. The regular method of proportioning piping as described on pages 135 to 139 results in equal friction per foot of length, but formula (72) gives equal friction, and therefore the desired distribution, for different lengths of piping.

This formula may be readily solved by means of the curve on page 140, which gives the fifth root of the various ratios of $(l_1 + 45\,d_1)$ to $(l_2 + 45\,d_2)$. This ratio should be applied after the piping has been laid out for equal friction per running foot according to the method explained in the preceding section.

Example. Assuming a piping system has been proportioned for equal friction per foot of length according to the method explained in the example on page 137, and that there are a number of branch pipes ten feet long and one branch pipe to a distant room is 50 feet long. To carry the desired amount of air, according to the method already referred to, we will assume the short pipes are to be 15 inches and the long pipe 12 inches in diameter. While friction in this long run will be the same per lineal foot, owing to the fact that it is longer than the other branches, total friction will be greater and air delivery will be less than desired.

Letting $l_1 = 10$ and $d_1 = 1.25$ as the length and diameter of the short branch, and $l_2 = 50$ and $d_2 = 1$ as the length and diameter of the long branch, we may determine the corrected diameter d_1' by means of the factor obtained from the curve on page 140. We will have

$$\frac{l_1 + 45\,d_1}{l_2 + 45\,d_2} = \frac{10 + 56.3}{50 + 45} = 0.698$$

and from the curve (page 140) the corresponding ratio

$$\frac{d_1'}{d_1} = 0.93 \text{ or } \frac{d_2'}{d_2} = \frac{1}{0.93} = 1.075$$

In this case diameter of the longer branch should be increased to

$$d_2' = 12 \times 1.075 = 12.9 \text{ inches.}$$

Piping Layout

Values in the tables on pages 144 to 152 are taken from the diagram and for rapid work may be found more convenient than the curves. They give directly the diameter of the branch pipe required to carry, with equal friction, any given percentage of the air carried in the main pipe whose diameter will be found across the top of the table.

In reducing from one pipe size to another the taper should be 1½ inches to the foot until the area is reduced to the size required.

The branches should leave the main at any angle less than 45°, preferably 30°, but it is not necessary to adhere to this rigidly.

Elbows of 90° should be made with a radius of 1½ diameters to the center of the pipe. In mains having high velocity two diameters is a better radius.

Outlets which discharge directly from the main or branches, as is often the case in industrial buildings, should be made about two diameters in length.

By the foregoing method of proportioning piping, it becomes unnecessary to consider the resistance of each section of pipe independently as the friction is constant per foot of length. It is simply necessary to know the length of the longest run of piping in feet, number and sizes of elbows, and diameter and velocity in the largest pipe, as the loss is exactly the same as though the entire amount of air was carried through the largest pipe the entire distance. It is usual to make the area of the largest pipe approximately equal to the area of the fan outlet.

Example. As an example of this method of figuring, assume 120 feet as the length of piping to the farthest outlet with a main pipe of 48 inches diameter and with three reductions of 39, 30 and 20 inches diameter, each containing one 90° elbow. We may then compute the friction in the following manner:

The main pipe is 48 inches or 4 feet in diameter.

120 feet is equivalent to $\frac{120}{4}$ or 30 diameters of 48-inch pipe.

1–48-inch elbow is equivalent to 10 diameters of 48-inch pipe.

1–39-inch elbow is equivalent to 10 diameters of 39-inch pipe or $\frac{39}{48} \times 10 = 8.13$ diameters of 48-inch pipe.

1–30-inch elbow is equivalent to 10 diameters of 30-inch pipe or $\frac{30}{48} \times 10 = 6.25$ diameters of 48-inch pipe.

1–20-inch elbow is equivalent to 10 diameters of 20-inch pipe or $\frac{20}{48} \times 10 = 4.17$ diameters of 48-inch pipe.

Then the total equivalent length will be $30 + 10 + 8.13 + 6.25 + 4.17 = 58.55$ diameters of 48-inch pipe.

The equivalent loss in velocity head will then be

$$58.55 \div 50 = 1.17$$

times the velocity head in the 48-inch main. Further, there is a velocity head remaining in the 20-inch pipe which gives an additional loss evidently of $^{20}/_{48}$ of one velocity head or 0.42 times the velocity head in the 48-inch main. This gives a total loss in the piping system, neglecting the loss of entrance of

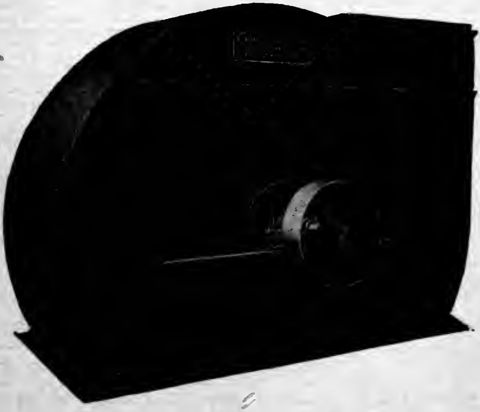
$$1.17+0.42=1.59$$

times the velocity head in the 48-inch main. If we allow a velocity in the 48-inch main of 2000 feet per minute the corresponding velocity head will be 0.25 inch. The loss in pressure in the piping system is

$$0.25\times1.59=0.398 \text{ inch.}$$

Carrying Capacity of Pipes

Carrying capacity of round ducts at various velocities may be found from the tables on pages 154 and 155. Capacity of rectangular ducts may be determined from the table of equivalent sizes on pages 156 and 157. Thus if we are to handle 20000 A. P. M. at a velocity of 1800 feet per minute a round pipe 46 inches in diameter should be used. In case a rectangular duct is to be used the size may be found by selecting from the table on page 157 the proper sizes to correspond to the dimension 46 inches in the body of the table. Thus we might use a 35×50, a 38×46, a 42×42, or any one of a number of other combinations.



Three-Quarter Housing Planoidal Type "L" Fan

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																								6	6	6	6	6	6
2															6	6	6	6	6	7	7	7	7	7	8	8	8	8	8
3											6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10
4								6	6	6	6	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11
5							6	6	6	7	7	7	8	8	8	8	9	9	9	10	10	10	11	11	11	11	12	12	12
6						6	6	7	7	7	8	8	8	9	9	9	10	10	10	10	11	11	11	12	12	12	13	13	13
7					6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	13	14	14
8				6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	11	12	12	12	13	13	14	14	14	15	15
9			6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	12	12	12	13	13	13	14	14	15	15	15	16
10		6	6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	12	13	13	14	14	14	15	15	16	16	16
11		6	6	7	7	7	8	8	9	9	10	10	10	10	11	12	12	12	13	13	14	14	15	15	15	16	16	17	17
12	6	6	6	7	7	8	8	9	9	9	10	10	11	11	12	12	12	13	13	14	14	15	15	15	16	16	17	17	18
13	6	6	7	7	7	8	8	9	9	10	10	11	11	12	12	12	13	13	14	14	15	15	16	16	16	17	17	18	18
14	6	6	7	7	8	8	9	9	10	10	10	11	11	12	12	13	13	14	14	15	15	16	16	16	17	17	18	18	19
15	6	7	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	15	16	16	17	17	18	18	19	19
16	6	7	7	8	8	9	9	10	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20
17	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20
18	7	7	7	8	8	9	9	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21
19	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21
20	7	7	8	8	9	9	10	10	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	21	21	22
21	7	7	8	8	9	10	10	11	11	12	12	13	13	14	15	15	16	16	17	17	18	18	19	19	20	20	21	22	22
22	7	8	9	9	9	10	10	11	11	12	12	13	13	14	15	15	16	16	17	17	18	18	19	20	20	21	21	22	22
23	7	8	9	9	9	10	10	11	12	12	13	13	14	14	15	15	16	17	17	18	18	19	19	20	21	21	22	22	23
24	7	8	9	9	9	10	11	11	12	12	13	13	14	15	15	16	16	17	17	18	19	19	20	20	21	21	22	23	23
25	7	8	9	9	10	10	11	11	12	12	13	14	14	15	15	16	17	17	18	18	19	20	20	21	21	22	22	23	24
26	8	8	9	9	10	10	11	11	12	13	13	14	14	15	16	16	17	17	18	19	19	20	20	21	21	22	23	23	24
27	8	8	9	9	10	10	11	12	12	13	13	14	15	15	16	16	17	18	18	19	19	20	21	21	22	22	23	23	24
28	8	8	9	9	10	11	11	12	12	13	14	14	15	15	16	17	17	18	18	19	20	20	21	21	22	23	23	24	24
29	8	8	9	9	10	11	11	12	13	13	14	14	15	16	16	17	18	18	19	19	20	21	21	21	22	23	24	24	25
30	8	8	9	10	10	11	11	12	13	13	14	15	15	16	16	17	18	18	19	20	20	21	21	22	23	23	24	24	25
31	8	9	9	10	10	11	12	12	13	13	14	15	15	16	17	17	18	19	19	20	20	21	22	22	23	24	24	25	25
32	8	9	9	10	10	11	12	12	13	14	14	15	15	16	17	18	18	19	19	20	21	21	22	23	23	24	24	25	26
33	8	9	9	10	11	11	12	13	13	14	14	15	16	16	17	18	18	19	20	20	21	22	22	23	24	24	25	25	26

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
1	6	7	7	7	7	7	7	8	8	8	8	8	8	8	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10
2	9	9	9	9	10	10	10	10	10	11	11	11	11	11	12	12	12	12	12	13	13	13	13	13	13	14	14	14	14
3	10	11	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17	17	17	17
4	11	12	12	12	13	13	13	14	14	14	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18	19	19	19	19
5	13	13	13	14	14	14	15	15	15	16	16	16	16	17	17	17	18	18	18	19	19	19	19	20	21	21	21	21	21
6	14	14	14	15	15	15	16	16	16	17	17	17	18	18	18	19	19	19	20	20	21	21	21	21	22	22	22	23	23
7	14	15	15	16	16	16	17	17	17	18	18	18	19	19	19	20	20	21	21	21	22	22	22	23	23	23	24	24	24
8	15	16	16	17	17	17	18	18	18	19	19	19	20	20	20	21	21	22	22	22	23	23	24	24	24	25	25	25	26
9	16	17	17	17	18	18	18	19	19	20	20	20	21	21	22	22	22	23	23	23	24	24	25	25	25	26	26	27	27
10	17	17	18	18	18	19	19	20	20	20	21	21	22	22	23	23	23	24	24	24	25	25	26	26	26	27	27	28	28
11	17	18	18	19	19	20	20	20	21	21	22	22	22	23	23	24	24	25	25	25	26	26	27	27	28	28	29	29	29
12	18	18	19	19	20	20	21	21	22	22	22	23	23	24	24	25	25	25	26	26	27	27	28	28	29	29	30	30	31
13	19	19	20	20	20	21	21	22	22	23	23	24	24	25	25	25	26	26	27	27	28	28	29	29	30	30	30	31	31
14	19	20	20	21	21	22	22	22	23	23	24	24	25	25	26	26	27	27	27	28	28	29	30	30	30	31	31	32	32
15	20	20	21	21	22	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	32	33
16	20	21	21	22	22	23	23	23	24	24	25	25	26	27	27	28	28	29	29	30	30	30	31	31	32	32	33	33	34
17	21	21	22	22	23	23	24	24	25	25	25	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35
18	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35	35
19	22	22	23	23	24	24	25	25	25	26	27	27	28	29	29	30	30	30	31	31	32	33	33	34	34	35	35	36	36
20	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	33	33	34	34	34	35	36	36	37
21	23	23	24	24	25	25	26	26	27	27	28	29	29	29	30	30	31	31	32	32	33	34	34	35	35	36	36	37	37
22	23	23	24	24	25	26	26	27	27	28	28	29	29	30	31	31	32	32	33	33	34	34	35	35	35	37	37	38	38
23	23	24	24	25	25	26	27	27	28	28	29	29	30	30	31	32	32	33	33	34	34	35	36	36	36	37	38	38	39
24	24	24	25	25	26	26	27	28	28	29	29	30	30	31	32	32	33	33	34	34	35	36	36	37	37	38	38	39	39
25	24	25	25	26	26	27	27	28	28	29	29	30	30	31	32	33	33	34	34	35	36	36	37	37	37	38	39	40	40
26	24	25	26	26	27	27	28	28	29	29	30	31	31	32	33	33	34	34	35	35	36	37	37	38	38	38	39	41	41
27	25	25	26	26	27	28	28	29	29	30	30	31	32	33	33	33	34	35	35	36	36	37	38	38	38	39	40	41	41
28	25	26	26	27	27	28	28	29	30	30	31	32	32	33	33	34	35	36	36	36	37	38	38	39	39	39	40	42	42
29	25	26	27	27	28	28	29	30	30	31	31	32	33	34	34	35	35	36	36	37	38	38	39	39	40	40	41	42	42
30	26	26	27	27	28	29	29	30	31	31	32	32	33	34	34	35	35	36	37	37	38	39	39	40	40	41	41	42	43
31	26	27	27	28	28	29	30	30	31	32	32	33	34	34	35	35	36	37	37	38	39	39	40	41	41	42	42	43	44
32	26	27	28	28	29	29	30	31	31	32	33	33	34	34	35	36	36	37	38	38	39	40	41	41	41	42	43	43	44
33	27	27	28	28	29	29	30	31	32	32	33	34	34	35	36	36	37	38	38	39	39	40	41	41	42	43	43	44	45

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																														
	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14	14	14	14	14	15	15	15	15	15	15
2	14	15	15	15	15	16	16	16	16	16	17	17	17	17	17	18	18	18	18	18	19	19	19	19	19	20	20	20	20	20	20
3	18	18	18	18	19	19	19	20	20	20	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25	25
4	20	20	20	20	21	21	21	22	22	22	22	23	23	23	23	24	24	24	25	25	25	25	26	26	26	27	27	27	27	28	28
5	21	22	22	22	23	23	23	24	24	24	25	25	25	26	26	26	26	27	27	27	27	28	28	28	29	29	29	30	30	30	30
6	23	23	24	24	25	25	25	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	31	32	32	32	33	33	33
7	25	25	25	26	26	27	27	28	28	28	28	29	29	29	30	30	30	31	31	32	32	32	33	33	33	34	34	34	35	35	35
8	26	26	27	27	28	28	28	29	29	30	30	30	31	31	31	32	32	32	33	33	33	34	34	35	35	35	36	36	37	37	37
9	27	28	28	28	29	29	30	30	31	31	31	32	32	32	33	33	34	34	34	35	35	35	36	36	37	37	38	38	38	39	39
10	28	29	29	30	30	31	31	31	32	32	33	33	33	34	34	35	35	35	36	36	37	37	37	38	38	39	39	39	40	40	41
11	30	30	31	31	31	32	32	33	33	34	34	34	35	35	36	36	37	37	37	38	38	39	39	39	40	40	41	41	42	42	42
12	31	31	32	32	33	33	33	34	34	35	35	35	36	36	37	37	38	38	39	39	39	40	40	41	41	42	42	43	43	43	44
13	32	32	33	33	34	34	34	35	35	36	36	36	37	37	38	38	39	39	40	40	40	41	41	42	42	43	43	44	44	45	45
14	33	33	34	34	35	35	35	36	36	37	37	38	38	38	39	39	40	40	41	41	42	42	43	43	44	44	44	45	45	46	46
15	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48
16	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	47	48	48	49
17	35	36	36	37	37	38	38	39	39	39	40	41	41	42	42	43	43	44	44	45	45	45	46	46	47	47	48	48	49	49	50
18	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48	48	49	49	50	50	51
19	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	46	47	47	48	48	49	49	50	50	51	51	52	52
20	37	38	38	39	40	40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48	48	49	49	50	50	51	51	52	53	53
21	38	39	39	40	41	41	41	42	42	43	44	44	45	45	46	46	47	47	48	48	49	49	50	50	51	52	52	53	53	54	54
22	39	39	40	41	41	42	42	43	43	44	44	45	45	46	46	47	48	48	49	49	50	50	51	51	52	52	53	53	54	54	55
23	39	40	41	41	42	42	43	43	44	44	45	46	46	47	47	48	48	49	49	50	51	51	52	52	53	53	54	54	55	55	56
24	40	41	41	42	43	43	44	44	45	45	46	46	47	47	48	49	49	50	50	51	51	52	53	53	54	54	55	55	56	56	57
25	41	41	42	42	43	44	44	45	45	46	46	47	48	48	49	49	50	51	51	52	52	53	53	54	55	55	56	56	57	57	58
26	42	42	43	43	44	44	45	45	46	47	47	48	48	49	49	50	51	51	52	52	53	53	54	55	55	56	56	57	57	58	59
27	42	43	43	44	44	45	45	46	47	47	48	48	49	50	50	51	51	52	52	53	54	54	55	56	56	57	57	58	58	59	60
28	43	43	44	44	45	45	46	47	47	48	48	49	50	50	51	51	52	53	53	54	54	55	56	56	57	57	58	59	59	60	60
29	43	44	44	45	45	46	47	47	48	48	49	50	50	51	51	52	53	53	54	54	55	56	56	57	57	58	59	59	60	60	61
30	44	44	45	45	46	47	48	48	49	49	50	50	51	52	52	53	53	54	55	55	56	56	57	58	58	59	59	60	61	61	62
31	44	45	45	46	47	47	48	48	49	50	50	51	52	52	53	53	54	55	55	56	57	57	58	58	59	60	60	61	61	62	63
32	45	45	46	47	47	48	49	49	50	50	51	52	52	53	54	54	55	55	56	57	57	58	59	59	60	60	61	62	62	63	64
33	46	46	47	48	48	48	49	50	50	51	52	52	53	53	54	55	55	56	57	57	58	59	59	60	60	61	62	62	63	64	65

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
34	8	9	9	10	11	11	12	13	13	14	15	15	16	16	18	18	19	19	20	21	21	22	22	23	24	24	25	26	26
35	8	9	10	10	11	12	12	13	13	14	15	15	16	17	18	18	19	19	20	21	21	22	23	23	24	25	25	26	27
36	8	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	19	20	20	21	21	22	23	23	24	25	26	26	27
37	9	9	10	10	11	12	12	13	14	14	15	16	16	17	18	19	19	20	21	21	22	23	23	24	25	25	26	27	27
38	9	9	10	10	11	12	12	13	14	15	15	16	16	17	18	19	19	20	21	21	22	23	23	24	25	25	26	27	27
39	9	9	10	11	11	12	13	13	14	15	15	16	17	18	18	19	19	20	21	22	22	23	23	24	25	26	26	27	28
40	9	9	10	11	11	12	13	14	14	15	16	16	17	18	18	19	20	20	21	22	23	23	24	24	25	26	27	28	28
41	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	19	20	21	21	22	23	23	24	25	26	26	27	28	28
42	9	10	10	11	12	12	13	14	14	15	16	17	17	18	19	19	20	21	21	22	23	24	24	25	26	26	27	28	29
43	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21	22	22	23	24	25	25	26	27	27	28	29
44	9	10	10	11	12	13	13	14	15	15	16	17	18	18	19	20	20	21	22	22	23	24	25	25	26	27	28	28	29
45	9	10	11	11	12	13	13	14	15	15	16	17	18	18	19	20	21	21	22	23	24	24	25	26	26	27	28	29	30
46	9	10	11	11	12	13	13	14	15	16	16	17	18	19	19	20	21	22	22	23	24	24	25	26	26	27	28	29	30
47	9	10	11	11	12	13	14	14	15	16	17	17	18	19	20	20	21	22	22	23	24	25	25	26	27	28	28	29	30
48	9	10	11	11	12	13	14	15	15	16	17	18	18	19	20	20	21	22	23	23	24	25	25	26	27	28	29	29	30
49	9	10	11	12	12	13	14	15	15	16	17	18	18	19	20	21	21	22	23	24	24	25	26	27	27	28	29	30	30
50	10	10	11	12	12	13	14	15	15	16	17	18	18	19	20	21	22	22	23	24	25	25	26	27	28	28	29	30	31
51	10	10	11	12	13	13	14	15	16	16	17	18	19	19	20	21	22	23	23	24	25	26	26	27	28	29	29	30	31
52	10	10	11	12	13	13	14	15	16	16	17	18	19	20	20	21	22	23	23	24	25	26	27	27	28	29	30	30	31
53	10	10	11	12	13	13	14	15	16	17	17	18	19	20	20	21	22	23	24	24	25	26	27	27	28	29	30	31	31
54	10	11	11	12	13	14	14	15	16	17	18	18	19	20	21	21	22	23	24	25	25	26	27	28	28	29	30	31	32
55	10	11	11	12	13	14	15	15	16	17	18	18	19	20	21	22	22	23	24	25	25	26	27	28	29	29	30	31	32
56	10	11	12	12	13	14	15	15	16	17	18	18	19	20	21	22	23	23	24	25	25	26	27	28	29	30	30	31	32
57	10	11	12	12	13	14	15	16	16	17	18	19	19	20	21	22	23	24	24	25	26	27	27	28	29	30	31	31	32
58	10	11	12	12	13	14	15	16	16	17	18	19	20	20	21	22	23	24	24	25	26	27	27	28	29	30	31	32	32
59	10	11	12	12	13	14	15	16	17	17	18	19	20	21	21	22	23	24	24	25	26	27	28	29	29	30	31	32	33
60	10	11	12	13	13	14	15	16	17	17	18	19	20	21	22	22	23	24	25	25	26	27	28	29	30	30	31	32	33
61	10	11	12	13	13	14	15	16	17	17	18	19	20	21	22	22	23	24	25	26	26	27	28	29	30	31	31	32	33
62	10	11	12	13	14	14	15	16	17	18	18	19	20	21	22	23	24	24	25	26	27	27	28	29	30	31	32	33	33
63	10	11	12	13	14	14	15	16	17	18	19	20	20	21	22	23	24	24	25	26	27	28	28	29	30	31	32	33	34
64	10	11	12	13	14	15	15	16	17	18	19	20	20	21	22	23	24	25	25	26	27	28	29	30	30	31	32	33	34
65	10	11	12	13	14	15	16	16	17	18	19	20	21	21	22	23	24	25	25	26	27	28	29	30	31	31	32	33	34
66	11	11	12	13	14	15	16	17	17	18	19	20	21	22	22	23	24	25	26	26	27	28	29	30	31	32	32	33	34

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
34	27	28	28	29	29	30	31	31	32	33	33	34	35	35	36	37	37	38	39	39	40	41	41	42	42	43	44	45	46
35	27	28	29	29	30	31	31	32	32	33	34	34	35	36	36	37	38	38	39	40	40	41	42	42	43	44	44	45	46
36	28	28	29	29	30	31	31	32	33	33	34	35	35	36	37	38	38	39	39	40	41	41	42	43	43	44	45	45	46
37	28	29	29	30	30	31	32	32	33	34	34	35	36	37	37	38	39	39	40	41	41	42	43	43	44	45	45	46	47
38	28	29	30	30	31	32	32	33	33	34	35	35	36	37	38	38	39	40	40	41	42	42	43	44	44	45	46	46	47
39	28	29	30	30	31	32	32	33	34	34	35	36	37	37	38	39	39	40	41	41	42	43	44	44	45	46	46	47	48
40	29	30	30	31	31	32	33	34	35	35	36	36	37	38	38	39	40	40	42	42	42	43	44	45	45	46	47	47	48
41	29	30	30	31	32	32	33	34	35	35	36	37	37	38	39	40	40	41	42	42	43	44	44	45	46	46	47	48	48
42	29	30	31	31	32	33	33	34	35	36	36	37	38	38	39	40	41	41	42	43	43	44	45	46	46	47	48	48	49
43	30	30	31	32	32	33	34	35	35	36	37	37	38	39	39	40	41	42	42	43	43	44	45	46	47	47	48	49	50
44	30	31	31	32	33	33	34	35	36	36	37	38	38	39	40	41	41	42	43	44	45	45	46	47	47	48	49	49	50
45	30	31	32	32	33	34	34	35	36	37	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	48	49	50	51
46	30	31	32	32	33	34	35	35	36	37	38	38	39	40	40	41	42	43	44	44	45	46	46	47	48	49	49	50	51
47	31	31	32	33	33	34	35	36	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	48	49	50	50	51
48	31	31	32	33	34	34	35	36	37	38	38	39	40	40	41	42	43	43	44	45	46	47	48	48	49	50	50	51	52
49	31	32	33	33	34	35	35	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	48	49	50	51	51	52
50	31	32	33	34	34	35	36	37	37	38	39	40	40	41	42	43	43	44	45	46	47	47	48	49	50	50	51	52	53
51	32	32	33	34	35	35	36	37	38	38	39	40	41	41	42	43	44	44	46	46	47	47	48	49	50	50	51	52	53
52	32	33	33	34	35	35	36	37	38	39	39	40	41	42	43	43	44	45	46	47	47	48	49	50	50	51	52	53	53
53	32	33	34	34	35	36	37	37	38	39	40	40	41	42	43	44	44	45	46	47	48	48	49	50	51	52	52	53	54
54	32	33	34	35	35	36	37	37	38	39	40	41	42	42	43	44	45	45	46	47	48	49	50	50	51	52	53	53	54
55	33	33	34	35	36	36	37	38	39	40	40	41	42	43	44	44	45	46	47	48	48	49	50	51	51	52	53	54	55
56	33	34	34	35	36	37	37	38	39	40	41	41	42	43	44	45	45	46	47	48	49	49	50	51	52	53	53	54	55
57	33	34	35	35	36	37	38	39	39	40	41	42	42	43	44	45	46	46	47	48	49	50	51	51	52	53	54	55	55
58	33	34	35	36	36	37	38	39	40	40	41	42	43	44	44	45	46	47	48	49	49	50	51	52	53	53	54	55	56
59	33	34	35	36	36	37	38	39	40	41	42	42	43	44	45	46	46	47	48	49	50	50	51	52	53	54	54	55	56
60	34	34	35	36	37	38	38	39	40	41	42	43	43	44	45	46	47	47	48	49	50	51	52	53	53	54	55	56	57
61	34	35	36	36	37	38	39	40	40	41	42	43	44	45	45	46	47	48	49	50	50	51	52	53	54	55	55	56	57
62	34	35	36	37	37	38	39	40	41	42	42	43	44	45	46	47	47	48	49	50	51	51	52	53	54	55	55	56	57
63	34	35	36	37	38	38	39	40	41	42	43	43	44	45	46	47	48	48	49	50	51	52	53	54	54	55	56	57	57
64	35	36	36	37	38	39	39	40	41	42	43	44	45	45	46	47	48	49	50	51	51	52	53	54	55	56	56	57	58
65	35	36	37	37	38	39	40	41	42	42	43	44	45	46	47	47	48	49	50	51	52	53	54	54	55	56	57	58	59
66	35	36	37	38	38	39	40	41	42	43	43	44	45	46	47	48	49	49	50	51	52	53	54	55	55	56	57	58	59

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																														
	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
34	46	46	47	48	48	49	50	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	60	61	62	62	63	64	64	65
35	46	47	48	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	61	61	62	63	63	64	65	65	66
36	47	48	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	61	61	62	63	63	64	65	65	66	66
37	47	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	61	61	62	63	63	64	65	65	66	67	67
38	48	48	49	50	50	51	52	52	53	54	54	55	56	56	57	58	58	59	60	60	61	62	62	63	64	64	65	66	67	68	68
39	48	49	50	50	51	52	52	53	54	54	55	56	56	57	58	58	59	60	60	61	62	62	63	64	64	65	66	66	67	68	68
40	49	49	50	51	51	52	53	54	54	55	56	56	57	58	58	59	60	60	61	62	63	63	64	65	65	66	67	67	68	69	69
41	49	50	51	51	52	53	54	54	55	56	56	57	58	58	59	60	60	61	62	63	63	64	65	65	66	67	67	68	69	69	70
42	50	50	51	52	53	53	54	55	55	56	57	58	58	59	60	60	61	62	62	63	64	65	65	66	67	67	68	69	70	70	71
43	50	51	52	52	53	54	55	55	56	57	57	58	59	59	60	61	62	62	63	64	64	65	66	66	67	68	69	69	70	71	71
44	51	52	52	53	54	54	55	56	56	57	58	59	59	60	61	62	62	63	64	64	65	66	67	67	68	69	69	70	71	71	72
45	51	52	53	53	54	55	56	56	57	58	58	59	60	60	61	62	63	63	64	65	65	66	67	68	68	69	70	71	71	72	73
46	51	52	53	54	55	56	57	57	58	58	59	60	60	61	62	62	63	64	65	65	66	67	68	68	69	70	70	71	72	73	73
47	52	53	54	54	55	56	57	58	58	59	59	60	61	61	62	63	64	64	65	66	67	67	68	69	70	70	71	72	73	73	74
48	53	53	54	55	56	57	57	58	59	59	60	61	61	62	63	64	64	65	66	66	67	68	69	69	70	71	72	72	73	74	75
49	53	54	54	55	56	57	58	59	59	60	60	61	62	63	63	64	65	66	66	67	68	69	69	70	71	72	72	73	74	75	75
50	53	54	55	56	57	58	58	59	60	60	61	62	62	63	64	65	65	66	67	68	68	69	70	71	71	72	73	74	74	75	76
51	54	55	55	56	57	58	58	59	60	61	61	62	63	64	65	65	66	67	68	68	69	70	70	71	72	73	74	74	75	76	76
52	54	55	56	57	57	58	58	59	60	61	62	63	63	64	65	66	66	67	68	69	69	70	71	72	73	73	74	75	75	76	77
53	55	55	56	57	58	59	59	60	61	61	62	63	64	65	66	67	68	68	69	70	70	71	72	73	74	75	75	75	76	77	78
54	55	56	57	58	58	59	60	60	61	62	63	64	64	65	66	67	68	68	69	70	70	71	72	73	74	75	75	76	77	78	78
55	55	56	57	58	58	59	60	61	62	63	63	64	65	66	67	67	68	69	70	70	71	72	73	73	74	76	76	76	77	78	79
56	56	56	57	58	59	60	61	61	62	63	64	65	65	66	67	68	69	70	71	71	72	73	73	74	75	76	77	77	78	79	79
57	56	57	58	58	59	60	61	62	63	63	64	65	66	67	67	68	69	70	71	71	72	73	74	75	75	76	77	78	79	79	80
58	56	57	58	59	60	61	61	62	63	64	64	65	66	67	68	69	69	70	71	72	72	73	74	75	76	76	77	78	79	80	80
59	57	58	59	59	60	61	62	63	63	64	65	66	67	67	68	69	70	71	71	72	73	74	75	76	76	77	78	79	80	80	81
60	57	58	59	60	61	61	62	63	64	65	66	67	68	68	69	70	71	71	72	73	74	74	75	76	77	78	78	79	80	81	82
61	58	58	59	60	61	62	63	63	64	65	66	67	68	68	69	70	71	72	72	73	74	75	76	76	77	78	79	80	80	81	82
62	58	59	60	60	61	62	63	64	65	66	66	67	68	69	70	70	71	72	73	74	75	75	76	78	78	79	79	80	80	82	83
63	58	59	60	61	62	63	64	64	65	66	67	68	68	69	70	71	72	73	73	74	75	76	77	78	78	79	80	81	82	82	83
64	59	60	61	61	62	63	64	65	66	66	67	68	69	70	71	71	72	73	74	75	76	76	77	78	79	80	80	81	82	83	.84
65	59	60	61	62	63	64	64	65	66	67	68	69	69	70	71	72	73	74	74	75	76	77	78	79	79	80	81	82	83	84	84
66	60	60	61	62	63	64	65	66	66	67	68	69	70	71	72	72	73	74	75	76	76	77	78	79	80	81	82	82	83	84	85

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
67	11	11	12	13	14	15	16	17	17	18	19	20	21	22	22	23	24	25	26	27	27	28	29	30	31	32	33	34	34
68	11	11	12	13	14	15	16	17	17	18	19	20	21	22	23	24	24	25	26	27	28	28	29	30	31	32	33	34	35
69	11	12	12	13	14	15	16	17	18	18	19	20	21	22	23	24	25	25	26	27	28	29	29	30	31	32	33	34	35
70	11	12	13	13	14	15	16	17	18	18	19	20	21	22	23	24	25	26	26	27	28	29	30	31	31	32	33	34	35
71	11	12	13	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	26	27	28	29	30	31	32	32	33	34	35
72	11	12	13	13	14	15	16	17	18	19	20	21	21	22	23	24	25	26	27	27	28	29	30	31	32	33	34	35	35
73	11	12	13	14	15	15	16	17	18	19	20	21	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	35	35
74	11	12	13	14	15	15	16	17	18	19	20	21	22	23	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36
75	11	12	13	14	15	16	16	17	18	19	20	21	22	23	24	24	25	26	27	28	29	30	30	32	32	33	34	35	36
76	11	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	26	27	28	29	30	31	32	33	34	34	35	36
77	11	12	13	14	15	16	17	18	18	19	20	21	22	23	24	25	26	27	27	28	29	30	31	32	33	34	35	35	36
78	11	12	13	14	15	16	17	18	18	19	20	21	22	23	24	25	26	27	27	28	29	30	31	32	33	34	35	36	37
79	11	12	13	14	15	16	17	18	19	19	20	21	22	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36	37
80	11	12	13	14	15	16	17	18	19	20	21	21	22	23	24	25	26	27	28	29	30	30	31	32	33	34	35	36	37
81	11	12	13	14	15	16	17	18	19	20	21	22	22	23	24	25	26	27	28	29	30	31	31	32	33	34	35	36	37
82	11	12	13	14	15	16	17	18	19	20	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	36	37
83	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25	26	27	28	29	30	31	32	33	34	35	36	37	38
84	12	13	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	35	36	37	38
85	12	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	35	36	37	38
86	12	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	35	36	37	38
87	12	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30	31	32	33	34	35	36	37	38
88	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	37	38
89	12	13	14	15	16	17	18	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
90	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
91	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	26	27	28	29	30	31	32	33	34	35	36	37	38	39
92	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36	37	38	39
93	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	31	32	33	34	35	36	37	38	39
94	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	38	39
95	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
96	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
97	12	13	14	15	16	17	18	19	20	21	23	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
98	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
99	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																												
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
67	35	36	37	38	39	39	40	41	42	43	44	45	45	46	47	48	49	50	51	51	52	53	54	55	56	57	57	58	59
68	35	36	37	38	39	40	40	41	42	43	44	45	46	47	47	48	49	50	51	52	53	53	54	55	56	57	58	59	60
69	36	36	37	38	39	40	41	42	43	43	44	45	46	47	48	49	49	50	51	52	53	54	55	56	56	57	58	59	60
70	36	37	38	38	39	40	41	42	43	44	45	45	46	47	48	49	50	51	52	53	53	54	55	56	57	58	59	59	60
71	36	37	38	39	39	40	41	42	43	44	45	46	47	47	48	49	50	51	52	53	54	54	55	56	57	58	59	60	60
72	36	37	38	39	40	41	41	42	43	44	45	46	47	48	49	49	50	51	52	53	54	55	56	57	57	58	59	60	61
73	36	37	38	39	40	41	42	43	44	44	45	46	47	48	49	50	50	51	52	53	54	55	56	57	58	59	59	60	61
74	37	38	39	39	40	41	42	43	44	45	45	46	47	48	49	50	51	52	53	54	55	55	56	57	58	59	60	61	62
75	37	38	39	40	40	41	42	43	44	45	46	47	48	48	49	50	51	52	53	54	55	56	57	57	58	59	60	61	62
76	37	38	39	40	41	42	43	43	44	45	46	47	48	49	50	51	51	52	53	54	55	56	57	58	59	60	60	61	62
77	37	38	39	40	41	42	43	44	45	45	46	47	48	49	50	51	52	52	53	54	55	56	57	58	59	60	61	62	63
78	38	38	39	40	41	42	43	44	45	46	47	47	48	49	50	51	52	53	54	55	56	57	58	58	59	60	61	62	63
79	38	39	40	40	41	42	43	44	45	46	47	48	49	49	50	51	52	53	54	55	56	57	58	59	59	60	61	62	63
80	38	39	40	41	41	42	43	44	45	46	47	48	49	50	51	52	53	53	54	55	56	57	58	59	60	61	62	63	64
81	38	39	40	41	42	43	44	44	45	46	47	48	49	50	51	52	53	54	55	56	56	57	58	59	60	61	62	63	64
82	38	39	40	41	42	43	44	45	46	47	48	48	49	50	51	52	53	54	55	56	57	58	59	60	60	61	62	63	64
83	38	39	40	41	42	43	44	45	46	47	48	49	50	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
84	39	40	41	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	57	58	59	60	61	62	63	64	65
85	39	40	41	42	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	58	59	60	61	62	63	64	65
86	39	40	41	42	43	44	45	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	63	64	65
87	39	40	41	42	43	44	45	46	47	48	49	50	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
88	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	54	55	56	57	58	59	60	61	62	63	64	65	66
89	40	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62	63	64	65	66
90	40	41	42	43	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
91	40	41	42	43	44	45	46	47	48	49	50	51	52	53	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
92	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	55	56	57	58	59	60	61	62	63	64	65	66	67
93	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
94	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
95	41	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
96	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	56	57	58	59	60	61	62	63	64	65	66	67	68
97	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
98	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
99	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69

DIAMETER OF BRANCH PIPE FOR DIFFERENT PER CENTS. OF TOTAL AIR IN MAIN PIPE

% of Air	Diameter of Main Pipe																														
	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
67	60	61	62	63	63	64	65	66	67	68	68	69	70	71	72	73	74	74	75	76	77	78	79	80	80	81	82	83	84	85	85
68	60	61	62	63	64	65	66	66	67	68	69	70	71	72	72	73	74	75	76	77	77	78	79	80	81	82	83	83	84	85	86
69	61	61	62	63	64	65	66	67	68	68	69	70	71	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	85	86
70	61	62	63	64	65	65	66	67	68	69	70	71	71	72	73	74	75	76	77	78	78	79	80	81	82	83	83	84	85	86	87
71	61	62	63	64	65	66	67	67	68	69	70	71	72	73	74	75	75	76	77	78	79	80	81	82	82	83	84	85	86	87	87
72	62	63	64	64	65	66	67	68	69	70	70	71	72	73	74	75	76	77	77	78	79	80	81	82	83	84	85	85	86	87	88
73	62	63	64	65	66	66	67	68	69	70	71	72	73	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	88
74	62	63	64	65	66	67	68	69	70	70	71	72	73	74	75	76	77	78	78	79	80	81	82	83	84	85	85	86	87	88	89
75	63	64	65	65	66	67	68	69	70	71	72	73	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	88	89
76	63	64	65	66	67	68	69	69	70	71	72	73	74	75	76	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90
77	63	64	65	66	67	68	69	70	71	72	72	73	74	75	76	77	78	79	80	81	81	82	83	84	85	86	87	88	89	90	90
78	64	65	66	66	67	68	69	70	71	72	73	74	75	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91
79	64	65	66	67	68	69	70	70	71	72	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	91
80	64	65	66	67	68	69	70	71	72	73	74	75	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
81	65	66	67	67	68	69	70	71	72	73	74	75	76	77	78	78	79	80	81	82	83	84	85	86	87	88	89	90	90	91	92
82	65	66	67	68	69	70	71	71	72	73	74	75	76	77	78	79	80	81	82	83	84	84	85	86	87	88	89	90	91	92	93
83	65	66	67	68	69	70	71	72	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	89	90	91	92	93
84	66	67	68	68	69	70	71	72	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	91	92	93
85	66	67	68	69	70	71	72	73	74	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	89	90	91	92	93	94
86	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	94
87	67	68	69	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92	93	94	95
88	67	68	69	70	71	72	73	74	75	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	92	93	94	95
89	67	68	69	70	71	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
90	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	96
91	68	69	70	71	72	73	74	75	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	96
92	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91	92	93	94	95	96	97
93	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	93	94	95	96	97
94	69	70	71	72	73	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98
95	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	89	90	91	92	93	94	95	96	97	98
96	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
97	70	71	72	73	74	75	76	77	78	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
98	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
99	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

Typical Layout of Piping Showing Main Ducts and Branch Outlets, as used with Fan System Heating Apparatus in a Machine Shop

CARRYING CAPACITY OF PIPES

This table specifies the diameters of pipes required for the passage of stated volumes of air at given velocities. The column, "Cubic feet of air per minute," indicates various quantities of air to be moved per minute. The figures at top of table give the velocities in feet per minute at which the air is to be moved, and the figures in the body of the table state the required diameters of pipes for the passage of the volumes mentioned at the given velocities.

Cubic Ft. of Air per Min.	Velocities											
	500	600	800	1000	1200	1500	1800	2000	2500	3000	3500	4000
200	9	8	7	7	6	6	6	6	6	6	6	6
400	13	11	10	9	8	8	7	7	6	6	6	6
600	15	14	12	11	10	9	8	8	7	7	6	6
800	18	16	14	13	12	10	9	9	8	8	7	7
1000	20	18	16	14	13	12	10	10	9	8	8	7
1200	21	20	17	15	14	13	11	11	10	9	9	8
1400	23	21	18	16	15	14	12	12	11	10	9	9
1600	25	23	20	18	16	15	13	13	11	11	10	9
1800	26	24	21	19	17	15	14	13	12	11	10	10
2000	28	25	22	20	18	16	15	14	13	12	11	10
2200	29	27	23	21	19	17	15	15	13	12	11	11
2400	30	28	24	21	20	18	16	15	14	13	12	11
2600	31	29	25	22	20	18	17	16	15	13	12	11
2800	33	30	26	23	21	19	18	16	15	14	13	12
3000	34	31	27	24	22	20	18	17	15	14	13	12
3200	34	32	28	25	23	20	19	18	15	15	13	13
3400	36	33	28	25	23	21	19	18	16	15	14	13
3600	37	34	29	26	24	21	20	19	16	15	14	13
3800	38	35	30	27	25	22	21	19	17	16	15	14
4000	39	35	31	28	25	22	21	20	18	16	15	14
4200	40	36	32	28	26	23	21	20	18	16	15	14
4400	41	37	32	29	26	24	22	21	18	17	16	15
4600	42	38	33	30	27	24	22	21	19	17	16	15
4800	42	39	34	30	28	25	22	21	19	18	16	15
5000	43	40	34	31	28	25	23	22	20	18	17	16
5200	44	40	35	31	29	25	24	22	20	18	17	16
5400			35	32	29	26	24	23	21	18	18	16
5600			36	33	30	27	24	23	21	19	18	17
5800			37	33	30	27	25	24	21	19	18	17
6000			38	34	31	28	25	24	21	20	18	17
6200			38	34	31	28	25	24	21	20	18	17
6400			39	35	32	28	26	25	22	20	19	18
6600			39	36	32	29	26	25	22	21	19	18
6800			40	36	33	29	27	25	23	21	19	18
7000			40	36	33	30	27	26	23	21	19	18
7200			41	37	34	30	28	26	23	21	20	19
7400			41	37	34	30	28	27	24	21	20	19
7600			42	38	34	31	28	27	24	22	20	19
7800			43	38	36	31	29	27	24	22	21	19
8000			43	39	36	32	29	28	25	22	21	20
8200				39	36	32	29	28	25	23	21	20
8400				40	36	33	30	28	25	23	21	20

CARRYING CAPACITY OF PIPES

Cu. Ft. of Air per Minute	Velocities									Cu. Ft. of Air per Minute	Velocities							
	1000	1200	1500	1800	2000	2500	3000	3500	4000		1200	1500	1800	2200	2500	3000	3500	4000
8600	40	37	33	30	29	25	23	21	20	54000	91	82	75	68	63	58	54	50
8800	41	37	33	30	29	26	24	22	21	55000	92	82	75	68	64	58	54	51
9000	41	38	34	31	29	26	24	22	21	56000	93	83	76	69	65	59	55	51
9200	41	38	34	31	30	26	24	22	21	57000	94	84	77	69	65	60	55	52
9400	42	38	34	31	30	27	24	22	21	58000	95	85	77	70	66	60	56	52
9600	42	39	35	32	30	27	25	23	21	59000	95	85	78	71	66	60	56	52
9800	43	39	36	32	30	27	25	23	21	60000	96	86	79	71	67	61	57	53
10000	43	40	36	32	31	28	25	23	22	61000	97	87	79	72	67	62	57	53
11000	45	41	37	33	31	29	26	24	23	62000	98	88	80	72	68	62	57	54
12000	47	43	39	35	34	30	28	25	24	63000				73	68	63	58	54
13000	49	45	40	37	35	31	29	27	25	64000				73	69	63	58	55
14000	51	47	42	38	36	33	30	28	26	65000				74	70	63	59	55
15000	53	48	43	40	38	34	31	28	27	66000				75	70	64	59	56
16000	55	50	45	41	39	35	32	29	28	67000				75	71	64	60	56
17000	56	51	46	42	40	36	33	30	28	68000				76	71	65	60	56
18000	58	53	47	43	41	37	34	31	29	69000				76	71	65	61	57
19000	60	54	49	44	42	38	34	32	30	70000				77	72	66	61	57
20000	61	56	50	46	43	39	35	33	31	71000				77	73	66	61	57
21000	63	57	51	47	44	40	36	34	31	72000				78	73	67	62	58
22000	64	58	52	48	45	41	37	34	32	73000				78	74	67	62	58
23000	65	60	53	49	46	42	38	35	33	74000				79	74	68	63	59
24000	67	61	55	50	47	42	39	36	34	75000				79	75	68	63	59
25000	68	62	56	51	48	43	40	37	34	76000				80	75	69	64	60
26000	70	63	57	52	49	44	40	38	35	77000				81	76	69	64	60
27000	71	65	58	53	50	45	41	38	36	78000				81	76	70	64	60
28000	72	66	59	54	51	46	42	39	36	79000				82	77	70	65	61
29000	73	67	60	55	52	47	42	39	37	80000				82	77	70	65	61
30000	75	68	61	56	53	47	43	40	38	81000				83	78	71	66	61
31000	76	69	62	57	54	48	44	41	38	82000				83	78	71	66	62
32000	77	70	63	57	55	49	45	41	39	83000				84	79	72	66	62
33000	78	72	64	58	56	50	45	42	39	84000				84	79	72	67	63
34000	79	73	65	59	56	50	46	43	40	85000				85	79	73	67	63
35000	81	74	66	60	57	51	47	43	40	86000				85	80	73	68	63
36000	82	75	67	61	58	52	47	44	41	87000				86	80	73	68	64
37000	83	76	68	62	59	52	48	44	42	88000				86	81	74	68	64
38000	84	77	69	63	60	53	49	45	42	89000				87	81	74	69	64
39000	85	78	70	63	60	54	49	46	43	90000				87	82	75	69	65
40000	86	79	71	64	61	55	50	46	43	91000				88	82	75	70	65
41000	87	79	71	65	62	55	50	47	44	92000				88	83	75	70	65
42000	88	81	72	66	63	56	51	47	44	93000				88	83	76	70	66
43000	89	82	73	66	63	57	51	48	44	94000				89	84	76	71	66
44000	90	82	74	67	64	57	52	48	45	95000				89	84	77	71	66
45000	91	83	75	68	65	58	53	49	46	96000				90	84	77	71	67
46000	93	84	75	69	65	59	53	50	46	97000				90	85	77	72	67
47000	93	85	76	70	66	59	54	50	47	98000				91	85	78	72	68
48000	95	86	77	70	67	60	55	50	47	99000				91	86	78	72	68
49000	95	87	78	71	68	60	55	51	48	100000				92	86	79	73	68
50000	96	88	79	72	68	61	56	51	48									
51000	97	89	79	73	69	62	56	52	49									
52000	98	90	80	73	70	62	57	53	49									
53000	99	90	81	74	70	63	57	53	50									

CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION

Side Rect. Duct	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	6.9	7.6	8.2	8.8																
9	7.3	8.0	8.7	9.3	9.9															
10	7.7	8.4	9.2	9.8	10.4	11.0														
11	8.0	8.8	9.6	10.2	10.9	11.5	12.1													
12	8.3	9.2	10.0	10.7	11.4	12.0	12.6	13.2												
13	8.7	9.6	10.4	11.1	11.8	12.5	13.1	13.7	14.3											
14	8.9	9.9	10.8	11.5	12.3	12.9	13.6	14.3	14.9	15.4										
15	9.2	10.2	11.1	11.9	12.7	13.4	14.1	14.7	15.3	16.0	16.5									
16	9.5	10.5	11.4	12.3	13.1	13.8	14.5	15.2	15.8	16.5	17.1	17.6								
17	9.8	10.8	11.8	12.6	13.5	14.2	15.0	15.7	16.3	17.0	17.6	18.2	18.7							
18	10.0	11.1	12.1	13.0	13.8	14.6	15.4	16.1	16.8	17.4	18.1	18.7	19.2	19.8						
19	10.3	11.4	12.4	13.3	14.2	15.0	15.8	16.5	17.2	17.9	18.6	19.2	19.8	20.4	20.9					
20	10.5	11.6	12.7	13.6	14.5	15.4	16.2	17.0	17.6	18.4	19.0	19.7	20.3	20.9	21.5	22.0				
22	11.0	12.1	13.2	14.2	15.2	16.1	16.9	17.8	18.5	19.2	19.9	20.6	21.3	21.9	22.5	23.1	23.6	24.2		
24	11.4	12.6	13.8	14.8	15.8	16.8	17.6	18.5	19.3	20.0	20.8	21.5	22.2	22.8	23.5	24.0	24.7	25.2	25.9	26.4
26	11.8	13.1	14.3	15.4	16.4	17.3	18.3	19.2	20.0	20.8	21.6	22.3	23.0	23.8	24.4	25.1	25.7	26.3	26.9	27.5
28	12.2	13.5	14.8	15.9	17.0	18.0	19.0	19.8	20.7	21.5	22.4	23.1	23.9	24.6	25.3	26.0	26.6	27.3	27.9	28.5
30	12.6	13.9	15.2	16.4	17.5	18.5	19.5	20.5	21.4	22.2	23.1	23.9	24.7	25.4	26.2	26.8	27.5	28.2	28.8	29.5
32	12.9	14.3	15.6	16.9	18.0	19.1	20.1	21.1	22.0	22.9	23.8	24.6	25.4	26.2	27.0	27.7	28.4	29.1	29.8	30.5
34	13.2	14.7	16.1	17.3	18.5	19.6	20.7	21.6	22.6	23.5	24.4	25.3	26.2	26.9	27.7	28.5	29.2	30.0	30.7	31.3
36	13.6	15.1	16.4	17.7	19.0	20.1	21.2	22.2	23.2	24.2	25.1	26.0	26.8	27.7	28.5	29.3	30.0	30.8	31.5	32.2
38	13.9	15.4	16.8	18.2	19.4	20.6	21.7	22.8	23.8	24.8	25.8	26.7	27.5	28.4	29.2	30.0	30.8	31.5	32.3	33.1
40	14.3	15.7	17.2	18.6	19.8	21.1	22.2	23.3	24.4	25.4	26.4	27.3	28.2	29.1	29.9	30.8	31.6	32.4	33.1	33.9
42	14.5	16.1	17.6	19.0	20.3	21.6	22.7	23.8	24.9	25.9	26.9	27.9	28.8	29.8	30.7	31.4	32.2	33.0	33.8	34.5
44	14.8	16.4	18.0	19.4	20.7	22.0	23.1	24.3	25.4	26.5	27.5	28.5	29.5	30.3	31.2	32.1	32.9	33.7	34.5	35.3
46	15.1	16.7	18.4	19.8	21.1	22.4	23.6	24.8	25.9	27.0	28.1	29.1	30.1	31.0	31.9	32.8	33.8	34.6	35.4	36.2
48	15.4	17.0	18.7	20.1	21.5	22.8	24.1	25.2	26.4	27.5	28.6	29.6	30.5	31.6	32.5	33.4	34.3	35.2	36.1	37.0
50	15.7	17.3	19.0	20.4	21.9	23.2	24.5	25.7	26.9	28.0	29.2	30.3	31.3	32.2	33.1	34.1	35.0	35.9	36.8	37.6
52	15.9	17.6	19.2	20.8	22.2	23.6	24.9	26.2	27.4	28.5	29.6	30.7	31.8	32.9	33.8	34.7	35.6	36.5	37.4	38.3
54	16.1	17.9	19.6	21.1	22.6	24.0	25.3	26.6	27.8	29.0	30.1	31.2	32.3	33.4	34.4	35.3	36.3	37.2	38.0	38.9
56	16.3	18.2	19.9	21.5	22.9	24.4	25.7	27.0	28.3	29.5	30.6	31.7	32.8	33.9	34.9	35.9	36.9	37.8	38.7	39.6
58	16.6	18.4	20.2	21.8	23.3	24.7	26.1	27.4	28.7	30.0	31.1	32.2	33.3	34.4	35.4	36.4	37.4	38.4	39.4	40.3
60	16.8	18.7	20.4	22.1	23.6	25.1	26.5	27.8	29.1	30.5	31.6	32.7	33.8	34.9	36.1	37.1	38.1	39.1	40.0	40.9
62	17.0	19.0	20.7	22.4	24.0	25.5	26.9	28.2	29.5	30.9	32.1	33.2	34.3	35.4	36.6	37.7	38.7	39.6	40.6	41.6
64	17.3	19.2	21.0	22.7	24.3	25.9	27.3	28.6	29.9	31.3	32.6	33.7	34.8	35.9	37.1	38.2	39.2	40.2	41.2	42.2
66	17.5	19.5	21.2	23.0	24.6	26.2	27.7	29.0	30.3	31.7	33.0	34.2	35.3	36.4	37.6	38.7	39.8	40.8	41.8	42.8
68	17.7	19.7	21.5	23.3	24.9	26.5	28.1	29.4	30.7	32.1	33.4	34.7	35.8	36.9	38.1	39.2	40.3	41.4	42.4	43.4

CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION

Side Rect. Duct	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	44	46	48
26	28.1	28.6																		
28	29.1	29.7	30.2	30.8																
30	30.1	30.7	31.3	31.9	32.5	33.0														
32	31.1	31.7	32.3	32.9	33.5	34.1	34.6	35.2												
34	32.0	32.7	33.3	33.9	34.5	35.1	35.7	36.3	36.8	37.4										
36	32.9	33.7	34.3	34.9	35.5	36.1	36.7	37.3	37.9	38.5	39.1	39.6								
38	33.8	34.6	35.3	35.9	36.5	37.1	37.7	38.4	39.0	39.5	40.1	40.7	41.2	41.8						
40	34.6	35.3	36.0	36.7	37.4	38.0	38.6	39.3	39.9	40.5	41.1	41.7	42.3	42.9	43.4	44.0				
42	35.2	36.0	36.8	37.6	38.3	39.0	39.6	40.3	40.9	41.5	42.1	42.7	43.4	44.0	44.5	45.1	46.2			
44	36.1	36.9	37.7	38.5	39.2	39.9	40.5	41.2	41.8	42.5	43.1	43.7	44.3	44.9	45.5	46.1	47.2	48.4		
46	37.0	37.8	38.5	39.3	40.0	40.8	41.5	42.2	42.9	43.5	44.2	44.8	45.4	46.0	46.6	47.2	48.4	49.5	50.6	
48	37.8	38.5	39.2	40.0	40.8	41.5	42.3	43.0	43.7	44.4	45.0	45.6	46.3	46.9	47.5	48.1	49.3	50.5	51.6	52.8
50	38.4	39.2	40.0	40.8	41.5	42.3	43.0	43.8	44.5	45.2	45.9	46.5	47.1	47.9	48.5	49.1	50.4	51.6	52.9	54.0
52	39.1	40.0	40.8	41.6	42.3	43.1	43.9	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.5	50.1	51.3	52.5	53.8	55.0
54	39.8	40.7	41.5	42.4	43.2	44.0	44.7	45.5	46.4	47.0	47.6	48.4	49.2	49.9	50.5	51.1	52.3	53.5	54.8	56.0
56	40.4	41.3	42.1	43.0	43.8	44.6	45.4	46.2	46.9	47.7	48.5	49.1	49.9	50.6	51.3	52.0	53.3	54.6	55.9	57.0
58	41.2	42.1	42.9	43.8	44.5	45.4	46.2	47.0	47.8	48.5	49.4	50.0	50.8	51.5	52.2	52.9	54.2	55.5	56.8	58.0
60	41.8	42.7	43.6	44.5	45.4	46.1	46.9	47.8	48.5	49.3	50.1	50.9	51.6	52.3	53.0	53.8	55.0	56.4	57.7	58.9
62	42.5	43.4	44.3	45.1	46.0	46.8	47.6	48.4	49.3	50.0	50.9	51.7	52.4	53.0	53.9	54.5	55.9	57.2	58.5	59.7
64	43.1	44.0	44.9	45.8	46.7	47.5	48.4	49.2	50.0	50.9	51.7	52.4	53.2	53.9	54.7	55.4	56.8	58.1	59.4	60.6
66	43.7	44.7	45.6	46.5	47.3	48.2	49.1	50.0	50.7	51.6	52.4	53.1	53.9	54.7	55.5	56.2	57.6	59.1	60.4	61.6
68	44.4	45.3	46.3	47.2	48.0	48.9	49.7	50.7	51.4	52.2	53.1	53.8	54.6	55.5	56.2	56.9	58.4	59.9	61.3	62.6
70	45.0	46.0	46.9	47.8	48.7	49.5	50.4	51.3	52.0	52.9	53.7	54.5	55.4	56.2	57.0	57.7	59.1	60.6	62.1	63.5
72	45.5	46.5	47.5	48.4	49.3	50.1	51.0	51.9	52.8	53.7	54.6	55.4	56.2	57.0	57.8	58.7	60.0	61.3	63.0	64.5

Sizes and Weights of Piping

Conduits through which air is conveyed may be either round or rectangular, depending on conditions to be met, and the terms piping or ducts are used for either cross section. The accompanying table gives the gauge of iron generally used for galvanized iron piping in heating and ventilating work, and also the weight per lineal foot of such pipes. For method of proportioning piping see page 135.

WEIGHT PER LINEAL FOOT AND GAUGES FOR GALVANIZED IRON PIPES ORDINARILY USED IN HEATING AND VENTILATING

Diam.	26 Gauge	Diam.	24 Gauge	Diam.	22 Gauge	Diam.	20 Gauge	Diam.	18 Gauge
10	2.70	20	7.02	30	12.17	40	18.76	50	30.90
11	2.96	21	7.26	31	12.54	41	19.20	51	31.40
12	3.22	22	7.70	32	12.93	42	19.61	52	32.00
13	3.48	23	8.04	33	13.34	43	20.30	53	32.66
14	3.74	24	8.38	34	13.73	44	20.74	54	33.20
15	4.01	25	8.72	35	14.10	45	21.20	55	34.10
16	4.27	26	9.05	36	14.50	46	21.62	56	34.65
17	4.53	27	9.40	37	14.90	47	22.10	57	35.21
18	4.87	28	9.75	38	15.29	48	22.60	58	35.84
19	5.14	29	10.07	39	15.60	49	23.00	59	36.40

GAUGES OF IRON USED FOR PIPING

Heating and Ventilating				Planing-Mill and Other Exhaust Systems	
Round Ducts		Rectangular Ducts			
Diam., Inches	Gauge	Width, Inches	Gauge	Diam., Inches	Gauge
6 to 19	26	4 to 18	26	Up to 8	24
20 to 29	24	19 to 30	24	9 to 14	22
30 to 39	22	31 to 60	22	15 to 20	20
40 to 49	20	61 to 118	20	21 to 30	18
50 and above	18	118 and above	18		

The tables on pages 160 and 161 give the weight of galvanized iron pipes in pounds per lineal foot for the various gauges ordinarily used in duct work, as also the square feet of surface per lineal foot for pipes from 4 to 86 inches in diameter. The weight per square foot for the different gauges is given at the bottom of the second table.

The figures to the right of the heavy line indicate the gauge of iron ordinarily used in heating and ventilating work. Thus a pipe 20 to 29 inches in diameter would be made of 24 gauge and a pipe from 30 to 39 inches of 22 gauge iron. The dotted line indicates the gauge to be used for planing-mill or other exhaust work. Other gauges than those indicated may be used under special circumstances, but those shown as above represent good average practice. The small table on page 158 gives the same information regarding weights of iron in tabular forms as explained above.

In the table on page 162 will be found the weights of black steel pipe of various diameters and gauges in pounds per lineal foot, and also the material used in square feet per running foot for the different sizes. The tables on pages 163 to 167 give the weight in pounds per lineal foot of rectangular galvanized iron ducts. These tables also show the gauge of iron ordinarily used for the different sizes of ducts. Thus a pipe say 20×50 inches would be made of No. 22 gauge iron and would weigh 17.5 pounds per lineal foot, while for a pipe 20×70 inches No. 20 gauge would be used, and the weight would be 26.3 pounds per running foot.

Niagara Conoidal Type "N" Fan

WEIGHT OF GALVANIZED IRON PIPES—POUNDS PER LINEAL FOOT

Diam. of Pipe	Sq. Ft. per Running Ft.	Number of Gauge, U. S. S.					
		26	24	22	20	18	16
4	1.13	1.13	1.47	1.69	1.97	2.56	3.10
5	1.39	1.39	1.80	2.08	2.43	3.19	3.82
6	1.65	1.65	2.14	2.47	2.89	3.79	4.54
7	1.91	1.91	2.48	2.86	3.34	4.39	5.25
8	2.18	2.18	2.83	3.27	3.81	5.01	6.00
9	2.44	2.44	3.17	3.66	4.27	5.61	6.71
10	2.70	2.70	3.51	4.05	4.72	6.21	7.42
11	2.96	2.96	3.85	4.44	5.18	6.80	8.14
12	3.22	3.22	4.18	4.83	5.63	7.40	8.85
13	3.48	3.48	4.52	5.22	6.09	8.00	9.57
14	3.74	3.74	4.86	5.61	6.54	8.60	10.28
15	4.01	4.01	5.21	6.01	7.01	9.22	10.86
16	4.27	4.27	5.55	6.40	7.47	9.82	11.74
17	4.53	4.53	5.85	6.79	7.92	10.42	12.45
18	4.87	4.87	6.33	7.30	8.51	11.18	13.36
19	5.14	5.14	6.68	7.71	9.00	11.80	14.11
20	5.40	5.40	7.02	8.10	9.45	12.42	14.85
21	5.59	5.59	7.26	8.39	9.78	12.85	15.36
22	5.92	5.92	7.70	8.88	10.35	13.60	16.25
23	6.18	6.18	8.04	9.27	10.81	14.40	17.00
24	6.45	6.45	8.38	9.67	11.30	14.84	17.71
25	6.71	6.71	8.72	10.06	11.74	15.41	18.41
26	6.97	6.97	9.05	10.45	12.20	16.00	19.15
27	7.33	7.33	9.40	10.85	12.67	16.62	19.87
28	7.50	7.50	9.75	11.27	13.13	17.26	20.60
29	7.75	7.75	10.07	11.63	13.58	17.81	21.30
30	8.10	8.10	10.54	12.17	14.20	18.62	22.25
31	8.36	8.36	10.87	12.54	14.63	19.20	23.00
32	8.62	8.62	11.20	12.93	15.10	19.84	23.70
33	8.88	8.88	11.56	13.34	15.56	20.42	24.40
34	9.15	9.15	11.90	13.73	16.00	21.08	25.18
35	9.41	9.41	12.23	14.10	16.48	21.65	25.85
36	9.67	9.67	12.57	14.50	16.91	22.22	26.60
37	9.93	9.93	12.91	14.90	17.40	22.84	27.30
38	10.19	10.19	13.25	15.29	17.81	23.40	28.00
39	10.46	10.46	13.60	15.60	18.31	24.02	28.70

NOTE: For explanation of heavy and dotted lines, see page 159.

WEIGHT OF GALVANIZED IRON PIPES—POUNDS PER LINEAL FOOT

Diam. of Pipe	Sq. Ft. per Running Ft.	Number of Gauge, U. S. S.					
		26	24	22	20	18	16
40	10.72	10.72	13.95	16.08	18.76	24.68	29.50
41	10.98	10.98	14.27	16.47	19.20	25.25	30.20
42	11.24	11.24	14.60	16.86	19.61	25.86	30.90
43	11.59	11.59	15.06	17.38	20.30	26.60	31.80
44	11.85	11.85	15.40	17.78	20.74	27.25	32.60
45	12.11	12.11	15.75	18.17	21.20	27.90	33.30
46	12.37	12.37	16.10	18.55	21.62	28.43	34.00
47	12.63	12.63	16.40	18.95	22.10	29.00	34.70
48	12.90	12.90	16.78	19.35	22.60	29.70	35.50
49	13.15	13.15	17.10	19.72	23.00	30.25	36.20
50	13.41	13.41	17.45	20.12	23.50	30.90	36.90
51	13.66	13.66	17.75	20.49	23.90	31.40	37.50
52	13.94	13.94	18.12	20.97	24.40	32.00	38.30
53	14.20	14.20	18.46	21.30	24.90	32.66	39.00
54	14.46	14.46	18.80	21.69	25.30	33.20	39.70
55	14.81	14.81	19.28	22.22	25.94	34.10	40.80
56	15.07	15.07	19.60	22.61	26.40	34.65	41.40
57	15.33	15.33	19.95	23.00	26.80	35.21	42.10
58	15.58	15.58	20.30	23.37	27.30	35.84	42.80
59	15.83	15.83	20.55	23.74	27.70	36.40	43.50
60	16.12	16.12	20.95	24.18	28.20	37.00	44.30
62	16.65	16.65	21.65	24.97	29.10	38.20	45.70
64	17.16	17.16	22.30	25.74	30.00	39.50	47.20
66	17.66	17.66	22.97	26.49	30.90	40.60	48.50
68	18.21	18.21	23.65	27.31	31.83	41.80	50.00
70	18.75	18.75	24.40	28.12	32.80	43.10	51.50
72	19.25	19.25	25.02	29.92	33.70	44.30	53.00
74	19.79	19.79	25.70	29.68	34.65	45.50	54.50
76	20.41	20.41	26.60	30.60	35.62	45.77	54.73
78	21.00	21.00	27.30	31.50	35.75	46.96	55.13
80	21.5	21.5	28.0	32.3	36.65	48.16	56.63
82	22.0	22.0	28.6	33.0	37.57	49.40	58.00
84	22.6	22.6	29.4	33.9	38.50	50.60	59.40
86	23.0	23.0	29.9	34.5	39.39	51.77	60.77
W'ght per Sq. Ft.		1.00	1.30	1.50	1.75	2.30	2.70

NOTE: For explanation of heavy line, see page 159.

WEIGHT OF BLACK STEEL PIPES—POUNDS PER LINEAL FOOT

Diam. of Pipe	Sq. Ft. per Running Ft.	Number of Gauge, U. S. S.						
		24	22	20	18	16	14	12
4	1.13	1.30	1.58	1.86	2.43	2.99	3.62	5.08
5	1.39	1.60	1.95	2.29	2.99	3.68	4.45	6.25
6	1.65	1.90	2.31	2.72	3.54	4.36	5.28	7.42
7	1.91	2.20	2.67	3.15	4.10	5.05	6.11	8.58
8	2.18	2.50	3.05	3.60	4.68	5.77	6.97	9.80
9	2.44	2.80	3.42	4.03	5.25	6.47	7.80	10.98
10	2.70	3.10	3.78	4.45	5.80	7.15	8.64	12.15
11	2.96	3.40	4.15	4.88	6.36	7.85	9.47	13.31
12	3.22	3.70	4.50	5.31	6.91	8.52	10.30	14.48
13	3.48	4.00	4.88	5.74	7.48	9.21	11.15	15.66
14	3.74	4.30	5.23	6.17	8.03	9.90	11.97	16.84
15	4.01	4.61	5.61	6.61	8.61	10.61	12.83	18.03
16	4.27	4.91	5.97	7.04	9.16	11.29	13.65	19.17
17	4.53	5.21	6.35	7.48	9.74	12.00	14.49	20.40
18	4.87	5.60	6.81	8.03	10.45	12.89	15.55	21.90
19	5.14	5.91	7.20	8.48	11.04	13.60	16.42	23.10
20	5.40	6.21	7.56	8.90	11.60	14.30	17.26	24.30
21	5.59	6.43	7.83	9.22	12.00	14.80	17.87	25.10
22	5.92	6.80	8.28	9.75	12.70	15.65	18.90	26.60
23	6.18	7.11	8.66	10.20	13.29	16.38	19.80	27.80
24	6.45	7.41	9.04	10.63	13.85	17.08	20.65	29.00
25	6.71	7.71	9.40	11.06	14.40	17.75	21.50	30.20
26	6.97	8.01	9.75	11.48	14.96	18.41	22.30	31.30
27	7.23	8.31	10.11	11.93	15.51	19.12	23.10	32.50
28	7.50	8.62	10.50	12.38	16.10	19.87	24.00	33.75
29	7.75	8.91	10.85	12.78	16.67	20.50	24.80	34.90
30	8.10	9.32	11.34	13.37	17.40	21.45	25.90	36.40
31	8.36	9.61	11.70	13.80	18.00	22.15	26.75	37.60
32	8.62	9.92	12.07	14.25	18.52	22.83	27.60	38.80
33	8.88	10.21	12.45	14.66	19.10	23.50	28.40	40.00
34	9.15	10.53	12.81	15.10	19.68	24.43	29.30	41.20
35	9.41	10.82	13.18	15.51	20.20	24.90	30.10	42.30
36	9.67	11.11	13.54	15.95	20.78	25.60	30.90	43.50
37	9.93	11.42	13.90	16.40	21.38	26.30	31.80	44.70
38	10.19	11.71	14.28	16.80	21.90	27.00	32.60	45.80
39	10.46	12.03	14.65	17.27	22.50	27.74	33.50	47.10
40	10.72	12.33	15.00	17.70	23.01	28.40	34.30	48.25
41	10.98	12.62	15.38	18.11	23.60	29.10	35.10	49.40
42	11.24	12.93	15.75	18.55	24.20	29.80	36.00	50.60
43	11.59	13.32	16.21	19.10	24.90	30.70	37.05	52.10
44	11.85	13.64	16.60	19.55	25.50	31.40	37.90	53.30
45	12.11	13.93	16.97	20.00	26.00	32.10	38.75	54.50
46	12.37	14.23	17.31	20.40	26.60	32.80	39.60	55.70
47	12.63	14.52	17.70	20.85	27.20	33.45	40.40	56.80
48	12.90	14.83	18.07	21.30	27.75	34.20	41.30	58.00
49	13.15	15.11	18.40	21.70	28.25	34.80	42.10	59.20
50	13.41	15.42	18.80	22.15	28.80	35.55	42.90	60.40
51	13.66	15.71	19.13	22.55	29.40	36.20	43.75	61.50
52	13.94	16.01	19.50	23.00	30.00	36.90	44.60	62.65
54	14.46	16.62	20.25	23.85	31.10	38.30	46.30	65.00
56	15.07	17.32	21.10	24.85	32.40	39.90	48.20	67.80
58	15.58	17.91	21.80	25.70	33.50	41.30	49.80	70.20
60	16.12	18.53	22.60	26.65	34.70	42.75	51.60	72.60
62	16.65	19.16	23.30	27.50	35.80	44.10	53.30	75.00
64	17.16	19.72	24.00	28.30	36.90	45.50	54.90	77.20
66	17.66	20.30	24.70	29.15	38.00	46.80	56.50	79.40
68	18.21	20.95	25.50	30.00	39.15	48.25	58.30	81.80
70	18.75	21.55	26.25	30.90	40.30	49.70	60.00	84.30
72	19.25	22.15	27.00	31.80	41.40	51.00	61.60	86.60
74	19.79	22.75	27.70	32.65	42.60	52.40	63.30	89.00

WEIGHT PER LINEAL FOOT FOR GALVANIZED IRON RECTANGULAR DUCTS

U. S. Standard Gauge

Size of Duct	26 Gauge												
	6	7	8	9	10	11	12	13	14	15	16	17	18
6	2.00	2.17	2.34	2.50	2.67	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0
7	2.17	2.34	2.50	2.67	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17
8	2.34	2.50	2.67	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17	4.34
9	2.50	2.67	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17	4.34	4.5
10	2.67	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17	4.34	4.5	4.67
11	2.84	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17	4.34	4.5	4.67	4.84
12	3.0	3.17	3.34	3.50	3.67	3.84	4.0	4.17	4.34	4.5	4.67	4.84	5.0
14	3.34	3.50	3.67	3.84	4.0	4.17	4.34	4.5	4.67	4.84	5.0	5.17	5.34
16	3.67	3.84	4.0	4.17	4.34	4.5	4.67	4.84	5.0	5.17	5.34	5.5	5.67
18	4.0	4.17	4.34	4.5	4.67	4.84	5.0	5.17	5.34	5.5	5.67	5.84	6.0

Size of Duct	24 Gauge											
	19	20	21	22	23	24	25	26	27	28	29	30
6	5.42	5.64	5.85	6.07	6.29	6.5	6.72	6.94	7.15	7.37	7.59	7.8
7	5.64	5.85	6.07	6.29	6.5	6.72	6.94	7.15	7.37	7.59	7.8	8.02
8	5.85	6.07	6.29	6.5	6.72	6.94	7.15	7.37	7.59	7.8	8.02	8.24
9	6.07	6.29	6.5	6.72	6.94	7.15	7.37	7.59	7.8	8.02	8.24	8.45
10	6.29	6.5	6.72	6.94	7.15	7.37	7.59	7.8	8.02	8.24	8.45	8.67
11	6.5	6.72	6.94	7.15	7.37	7.59	7.8	8.02	8.24	8.45	8.67	8.89
12	6.72	6.94	7.15	7.37	7.59	7.8	8.02	8.24	8.45	8.67	8.89	9.10
14	7.15	7.37	7.59	7.8	8.02	8.24	8.45	8.67	8.89	9.10	9.32	9.54
16	7.59	7.8	8.02	8.24	8.45	8.67	8.89	9.10	9.32	9.54	9.76	9.97
18	8.02	8.24	8.45	8.67	8.89	9.10	9.32	9.54	9.76	9.97	10.2	10.42
20	8.45	8.67	8.89	9.10	9.32	9.54	9.76	9.97	10.2	10.42	10.64	10.85
22	8.89	9.10	9.32	9.54	9.76	9.97	10.2	10.42	10.64	10.85	11.06	11.29
24	9.32	9.54	9.76	9.97	10.2	10.42	10.64	10.85	11.06	11.29	11.5	11.72
26	9.76	9.97	10.2	10.42	10.64	10.85	11.06	11.29	11.5	11.72	11.9	12.13
28	10.2	10.42	10.64	10.85	11.06	11.29	11.5	11.72	11.9	12.13	12.35	12.56
30	10.64	10.85	11.06	11.29	11.5	11.72	11.9	12.13	12.35	12.56	12.78	13.0

WEIGHT PER LINEAL FOOT FOR GALVANIZED IRON RECTANGULAR DUCTS

U. S. Standard Gauge

Size of Duct	22 Gauge														
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
6	9.25	9.5	9.75	10.0	10.25	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75
7	9.5	9.75	10.0	10.25	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0
8	9.75	10.0	10.25	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25
9	10.0	10.25	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5
10	10.25	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75
11	10.5	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0
12	10.75	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25
13	11.0	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5
14	11.25	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75
15	11.5	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0
16	11.75	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25
17	12.0	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5
18	12.25	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75
19	12.5	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0
20	12.75	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25
21	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5
22	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75
23	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0
24	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25
26	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75
28	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25
30	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75
32	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25
34	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75
36	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25

WEIGHT PER LINEAL FOOT FOR GALVANIZED IRON RECTANGULAR DUCTS

U. S. Standard Gauge

Size of Duct	22 Gauge														
	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
6	13.0	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5
7	13.25	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75
8	13.5	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0
9	13.75	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25
10	14.0	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5
11	14.25	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75
12	14.5	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0
13	14.75	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25
14	15.0	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5
15	15.25	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75
16	15.5	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0
17	15.75	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25
18	16.0	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5
19	16.25	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75
20	16.5	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0
21	16.75	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25
22	17.0	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25	20.5
23	17.25	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25	20.5	20.75
24	17.5	17.75	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25	20.5	20.75	21.0
26	18.0	18.25	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25	20.5	20.75	21.0	21.25	21.5
28	18.5	18.75	19.0	19.25	19.5	19.75	20.0	20.25	20.5	20.75	21.0	21.25	21.5	21.75	22.0
30	19.0	19.25	19.5	19.75	20.0	20.25	20.5	20.75	21.0	21.25	21.5	21.75	22.0	22.25	22.5
32	19.5	19.75	20.0	20.25	20.5	20.75	21.0	21.25	21.5	21.75	22.0	22.25	22.5	22.75	23.0
34	20.0	20.25	20.5	20.75	21.0	21.25	21.5	21.75	22.0	22.25	22.5	22.75	23.0	23.25	23.5
36	20.5	20.75	21.0	21.25	21.5	21.75	22.0	22.25	22.5	22.75	23.0	23.25	23.5	23.75	24.0

WEIGHT PER LINEAL FOOT FOR GALVANIZED IRON RECTANGULAR DUCTS

U. S. Standard Gauge

20 Gauge

Size of Duct	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
6	19.9	20.4	21.0	21.6	22.1	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0
8	20.4	21.0	21.6	22.1	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6
10	21.0	21.6	22.1	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2
12	21.6	22.1	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8
14	22.1	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4
16	22.8	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9
18	23.4	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5
20	23.9	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1
22	24.5	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7
24	25.1	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3
26	25.7	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9
28	26.3	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4
30	26.7	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0
32	27.4	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6
34	28.0	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2
36	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8
38	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3
40	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9
42	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5
44	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0
46	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6
48	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2
50	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8
52	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4
54	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0

WEIGHT PER LINEAL FOOT FOR GALVANIZED IRON RECTANGULAR DUCTS

U. S. Standard Gauge

Size of Duct	20 Gauge													
	92	94	96	98	100	102	104	106	108	110	112	114	116	118
6	28.6	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2
8	29.2	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8
10	29.8	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3
12	30.4	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9
14	30.9	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5
16	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0
18	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6
20	32.7	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2
22	33.3	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8
24	33.9	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4
26	34.4	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0
28	35.0	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6
30	35.6	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2
32	36.2	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8
34	36.8	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4
36	37.3	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0
38	37.9	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5
40	38.5	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0
42	39.0	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6
44	39.6	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2
46	40.2	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2	47.8
48	40.8	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2	47.8	48.4
50	41.4	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2	47.8	48.4	49.0
52	42.0	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2	47.8	48.4	49.0	49.6
54	42.6	43.2	43.8	44.4	45.0	45.5	46.0	46.6	47.2	47.8	48.4	49.0	49.6	50.2

PART IV

APPARATUS

The essential elements embodied in most installations using fans, more especially those for heating, ventilating, or similar work, are the fan, heater, ducts or piping system, and some form of motive power for driving the fan. In this section will be found complete data relative to the performance and dimensions of fans, heaters and engines, together with detailed directions for making fan tests. Data on the performance and dimensions of cast iron heaters are also given.

SECTION I

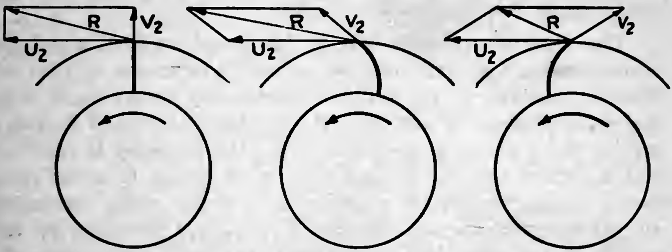
FANS

Fan Design

Centrifugal fans may be roughly divided into two classes, those having rotors with straight radial blades, and those having rotors with blades curved with reference to their direction of rotation. Curved blade fans have quite diverse characteristics, depending on whether they are curved forward or backward with reference to their direction of rotation. The mathematical theory of the radial blade fan is very completely and clearly discussed in Prof. Carpenter's book on Heating and Ventilation.

In any centrifugal fan there are two separate and independent sources of pressure. First, pure centrifugal force due to the rotation of an enclosed column of air. Second, kinetic energy contained in the air by virtue of its velocity upon leaving the periphery of the fan rotor. The amount of centrifugal force imparted to the air depends largely upon the ratio of the tangential or rotational velocity of the air leaving the periphery of the rotor to the tangential or rotational velocity of the air entering the fan at the heel of the blades.

When the flow of air through the rotor of a fan is partially obstructed the centrifugal effect in the rotor produces a compression corresponding to the centrifugal force, which is known as static pressure. On the other hand, the kinetic energy of the air leaving the periphery of the rotor must first be converted largely into potential energy in the form of static pressure before being serviceable. This conversion from kinetic energy or velocity into potential energy or static pressure is ordinarily accomplished in the scroll formation of the fan housing. A still further conversion is often secured, where the velocity leaving the outlet is high, by means of a diverging nozzle on the outlet of the fan. The principle covering the design and application of such nozzles is discussed on page 122.



STRAIGHT FORWARD BACKWARD

TYPES OF FAN BLADES.

The accompanying diagrams represent the parallelogram of forces for the three general types of blades, the first a straight blade, the second a blade bent forward and the third where the blade is bent backward. The line U_2 represents the tip speed of the wheel and the line V_2 represents the radial velocity of the air leaving the tip of the blade. The diagonal line **R** then represents the actual velocity of the air with respect to the fan casing.

The amount of total pressure developed by a straight blade fan may be determined by means of the following formula:

$$p = \frac{(U_2^2 - U_1^2) + MU_2^2 - (1\text{-}M)\ V_2^2 - (NV_o)^2}{V_p^2}; \qquad (73)$$

where p = total press. developed by fan.
V_o = velocity of air through inlet.
V_p = vel. corresponding to unit press.
V_2 = radial vel. of air leaving tip of blades.
U_1 = lineal vel. at heel of blades.
U_2 = lineal vel. at tip of blades.
M = per cent. velocity pressure conversion in fan scroll.
N = ratio of actual to effective area of inlet.

It will be noticed from the two diagrams of curved blade wheels that when the blade is bent forward an accelerated velocity will be obtained, while with the blades bent backward the opposite effect will be the result. This explains how it is possible to build a fan with a small wheel, such as is used in the multiblade type, and obtain the desired pressure and velocity without using excessive speeds. By curving the blades forward a pressure greater than that due to the peripheral velocity is obtained, as indicated in the diagram.

The velocity of the air leaving the tip of the blades and the corresponding velocity pressure is greatly in excess of that ordinarily required in the piping system, and at the same time the static pressure is too low. By enclosing the wheel in a casing having a properly designed scroll, this velocity is reduced, and a part of the velocity pressure is converted to static pressure. Since the static pressure due to the wheel varies as the difference of the squares of the rotational velocities at the periphery and inlet, it is evident that the shorter the blade the greater must be the dependence on the scroll-shaped housing to obtain the desired static pressure. For this reason the proper design of the housing is of greater importance in the case of a short blade multivane type of fan than with the older styles.

There are frequently cases where a fan is to be direct connected to a high speed unit, where the corresponding pressure obtained would be greater than required. In this case the backward bent blade is used, since, as may be noticed from the diagram, a pressure less than that corresponding to the peripheral velocity is then obtained.

The standard steel plate fan is essentially a straight blade fan, as compared with the later styles of short curved blade multivane type, although, as just shown, when the tips of the blades are bent either forward or backward the fan will have different characteristics from one with straight blades. This fan as ordinarily built does not give as high an efficiency as the multivane type owing to the fact that it is designed for large capacity rather than for high efficiency. **But if these long blade fans are built according to special design they may be made to give greater efficiency than may be obtained from the curved short blade fans.** This calls for a tall narrow fan with the inlet diameter smaller than that used on the standard fan. It may be readily shown that there is a certain diameter of inlet that will give maximum economy of operation. If the diameter is increased the loss by impact at the heel of the blades is increased as the square of the diameter, and the loss by entrance is decreased as the fourth power of the diameter. The opposite holds true in case the inlet diameter is decreased.

The proper size of the fan inlet depends on the cubic feet of air per revolution handled by the fan. It has been determined both mathematically and experimentally that the most efficient diameter of inlet is given by the simple relationship

$$D_1 = C\sqrt[3]{\frac{Q}{N}} \tag{74}$$

where D_1 = inlet diameter in feet.
Q = cubic feet of air per minute.
N = revolutions per minute.
C = a factor determined experimentally, and is practically a constant for all ratios of inlet diameter to wheel diameter.

COMPARATIVE EFFECT OF BLAST-WHEEL PROPORTIONS UPON THE EFFECT OF STRAIGHT BLADE FANS OPERATING AT THE SAME CAPACITY AND PRESSURE

Ratio of Dia. Inlet to Dia. Wheel at Perip.	Per Cent. Relative Diameter		Per Cent. Relative Width	Per Cent. Relative H. P.	Per Cent. Relative Speed
	Wheel	Inlet			
0.700	82.0	91.9	108.9	112.3	123.0
0.650	93.2	97.5	102.5	104.0	109.5
0.625	100.0	100.0	100.0	100.0	100.0
0.600	106.9	102.6	97.5	96.7	92.7
0.550	123.5	108.8	92.1	91.0	78.2
0.500	144.9	116.6	85.9	86.8	64.5
0.450	170.8	123.0	81.3	83.4	53.3
0.400	206.5	132.4	75.5	80.0	43.1
0.350	255.0	142.8	70.1	77.5	34.6

It may be noted from the accompanying table that the essential factor in the design of straight blade fans is the diameter of the inlet, and that the smaller the inlet as compared to the diameter of the wheel, the greater will be the efficiency obtained. This table is based on the assumption that a value of 62.5 per cent. for the above ratio be used to represent the average standard fan, and the other figures show comparative values for other ratios. It will be seen from the second and fourth columns that the height of the fan increases rapidly while the width decreases. This means, then, that these special high efficiency fans are tall and narrow, which naturally makes them more expensive than the ordinary commercial steel plate fan.

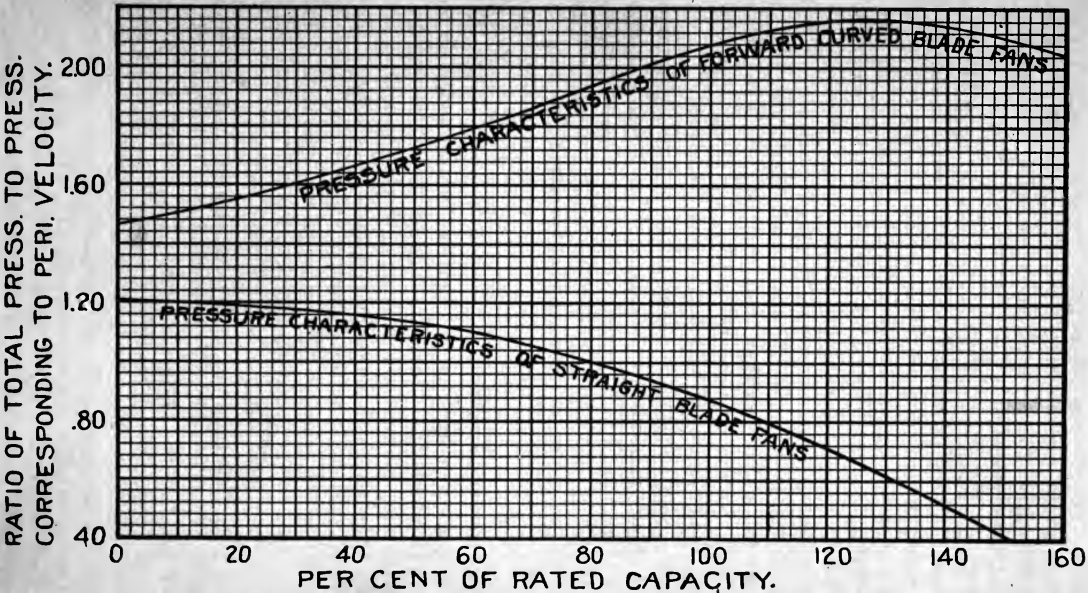
These special tall narrow fans are frequently used for induced draft work, partly because the narrow wheel makes a shorter over-hang on the fan bearing, and partly because they may be operated at lower speed and are therefore more suitable for direct connection to steam engines. A table of special induced draft fans will be found on pages 328 to 330, giving the size of engine and dimensions of fan for various boiler capacities.

Pressure Characteristics

The relative performance of the different styles of fans may be shown by the performance curves given for each style in Section III. The diagrams on pages 214 and 215 or on pages 224 and 225 are typical of the straight blade fan, while the diagram on page 276 shows the performance of the Niagara Conoidal fan, it being typical of the forward curved blade style.

In making the tests on these fans from which the diagrams referred to were computed, the fan was operated at constant speed with varying sized discharge orifices. Horsepower, pressure and capacity readings were taken and the efficiency calculated. The horsepower, pressure and efficiency were then plotted to capacity, giving the performance curves of this test fan. This set of curves shows the power consumption increasing with the capacity, but not at the same ratio. The efficiency increases to a maximum and then decreases to zero. The rating of the fan may be taken at any point adopted as a standard, but the desirable point will generally be determined by the point of maximum efficiency.

As will be noted from the diagrams already referred to, the relative pressure developed by centrifugal fans will differ for fans having straight or curved blades. A further comparison of the two types may be made from the diagram on page 173. The two curves indicate the ratio of the total pressure developed to the pressure corresponding to the peripheral velocity of the wheel, when operating at different per cents. of the fan's rated



Comparison of Forward Curved and Straight Blade Fans at Constant Speed capacity. Thus we see that at rated capacity the straight blade fan gives a total pressure of 87 per cent. and the forward curved blade type gives 208 per cent. of the pressure corresponding to the peripheral velocity.

When the Niagara Conoidal fan is operated up to 50 per cent. overload the total pressure increases, but when operating at less than rated capacity the pressure decreases. Just the opposite holds true in the case of the straight blade fan. From this we note that if a forward curved blade fan is intended to operate at a certain pressure and capacity and if for any reason, such as resistance greater than expected, the quantity of air handled is less than the fan's rating for the speed maintained, the total pressure will also be less than that specified. With the straight blade fan just the opposite holds true, for as the capacity is reduced the pressure will increase, at constant speed.

Care should be taken in the selection of a fan with forward curved blades in case it is to be driven with a motor. If for any reason there should be a tendency to operate at over capacity both the air quantity and the pressure will increase, which may overload the motor in case sufficient margin has not been allowed.

Special Types and Features

There are numerous special types of fans intended to meet various requirements. Some of these, as for instance foundry and forge shop blowers and exhausters or planing-mill exhausters, are adaptations of the ordinary straight blade fans. There are other types, such as the disc or propeller wheel, that differ essentially in the principle of their design and operation. These special types will be found described under their proper heading, together with their capacity and dimension tables.

The steel plate fans may be divided into two classes, namely, blower or exhauster, depending on whether they have two inlets or only one. With the double inlet fan, or blower, we have the total inlet area divided between the two sides of the housing, therefore each inlet may be made smaller in diameter for the same size of fan wheel, and so approach the more efficient type of fan as indicated in the table on page 171. For this reason the steel plate blower is a more efficient fan than the single inlet fan, or exhauster. Either may be made full housing or three-quarter housing, depending on the size and requirements. The multivane fan as ordinarily built is a single width fan with but one inlet. These are also built in a double width style, with two inlets, being essentially two fans placed back to back. They have the same characteristics as regards full or three-quarter housing, as also the angle of discharge, as has the steel plate exhauster.

Both the steel plate and the multivane fans are ordinarily built with a bearing on each side of the housing. In the case of the exhauster, where any substance is to be handled that would be injurious to the bearing located in the intake, they are usually made with an overhung wheel, a pedestal supporting an extra bearing being attached to the back of the housing. Special exhausters, as for instance planing-mill exhausters, are built with an overhanging wheel in order to avoid obstructing the inlet of the fan. Induced draft fans are built with an overhung wheel to avoid drawing the hot gases over the bearing. In any fan handling hot gases the bearing attached to the back of the housing should be of a special water cooled type to avoid heating.

The regular discharges of fans and blowers are designated as top or bottom horizontal discharge, up or down blast, and special, which are described by giving the angle of the discharge from the horizontal. The hand of a fan or blower is determined by the side on which the pulley or engine is located. Standing facing or nearest to the discharge outlet, the fan is right or left hand, according to whether the pulley is on the right- or left-hand side.

Horsepower of Fan

Each cubic foot of air per minute moved against a total pressure of one inch water gauge, equivalent to 0.577 oz. per square inch, or 5.19 pounds per square foot, represents the expenditure of 5.19 foot-pounds of work. We then have as the theoretical expenditure of energy in doing this work

$$\frac{5.19}{33000} = 0.000157 \text{ H. P.}$$

and also

$$\frac{1}{0.000157} = 6370 \text{ A. P. M.}$$

That is, with perfect efficiency, it will require 0.000157 H. P. to move one cubic foot of air per minute against a pressure of one inch, or 6370 cu. ft. of air per minute moved against one inch pressure will require one horsepower. Assuming a fan efficiency of 60 per cent. will give 0.000261 H. P. per cubic foot of air per minute per inch total pressure

$$\text{H. P.} = \frac{\text{A. P. M.} \times 0.000157 \times \text{total press. in inches}}{\text{total efficiency}} \qquad (75)$$

or

$$\text{H. P.} = \frac{\text{A. P. M.} \times 0.000157 \times \text{static press. in inches}}{\text{static efficiency}} \qquad (76)$$

where total or static efficiency refers to the efficiency based respectively on the total or static pressure. The ratio of total to static pressure will remain constant for any style of fan at rated capacity but will vary for the different types.

In the case of straight blade fans we may determine the horsepower for any given air delivery by assuming twice the pressure corresponding to the peripheral velocity with a corresponding efficiency of 100 per cent. This will give approximately the true horsepower regardless of actual pressure or efficiency obtained. Thus if we have a straight blade fan delivering 30000 A. P. M. at 230 R. P. M. with a fan wheel 83½ inches in diameter, we will have a peripheral velocity of 5040 feet per minute, and twice the pressure corresponding to the peripheral velocity will be 3.17 inches. Then the horsepower required by the fan will be

$$\text{H. P.} = 30000 \times 0.000157 \times 3.17 = 14.9.$$

Relations of Total, Static and Velocity Pressure

In fan work air is delivered against a certain **static pressure** or resistance of the system and in addition has imparted to it a certain velocity at the fan outlet. This velocity is dependent on the amount of air required and on the area of the fan outlet, and the **velocity pressure** expressed in inches corresponding to this velocity may be determined from the formula (see page 20)

$$p_v = \left(\frac{\text{velocity}}{4005}\right)^2 = \text{inches of water}$$

where the term velocity refers to the velocity of the air through the fan outlet in feet per minute.

When it is desired to express the velocity pressure in ounces per square inch the following formula should be used:

$$p_v = \left(\frac{\text{velocity}}{5273}\right)^2 = \text{oz. per sq. in.}$$

The total energy imparted to the air is composed of the static pressure of the system and the energy of discharge corresponding to the velocity pressure or velocity head as it is termed in hydraulics. The total pressure is the sum of the velocity pressure at the fan outlet plus the static pressure produced, and is the pressure upon which the performance and efficiency of the fan is usually based. In the case of an exhaust system, the static head on the fan should be taken as the difference in static pressure at the inlet and outlet of the fan. The method to be used in making these various pressure determinations is fully explained under "Fan Testing," Part IV, Section II.

The ratio of static to velocity pressure at the fan outlet is very important in fan engineering. This ratio varies as the capacity of the fan is varied at constant speed, and bears a definite experimental relationship to the efficiency of the fan. The rated fan performances which represent the most desirable conditions of operation are based on certain relationships of static to velocity pressure. For instance, the rated performance of the Planoidal fan is based on a relationship of

$$\frac{p_s}{p_v} = 3.88$$

The performance of the Planoidal fan with reference to this ratio is shown by the diagram on page 215. As an illustration of its use we will assume an 80-inch Planoidal exhauster operating against a static pressure of ¾ inch and delivering 12000 cu. ft. air per minute. Since the outlet of this fan is 5.54 sq. ft. (see table on page 207) the velocity at the fan outlet will be $12000 \div 5.54 = 2170$ ft. per minute, and the velocity pressure will be

$$p_v = \left(\frac{2170}{4005}\right)^2 = 0.294 \text{ in.}$$

The ratio of static to velocity pressure will then be

$$\frac{p_s}{p_v} = \frac{0.75}{0.294} = 2.55$$

From the diagram on page 215 we find that with the above ratio, the fan will be operating at 111.5 per cent. of rated capacity, with correspondingly increased power consumption and lowered efficiency. Further examples illustrating the application of these diagrams will be found under "Selection of a Fan" on page 182.

For certain kinds of work a low velocity in the piping system is desired, while in other cases it is necessary to maintain a high velocity. In case a lower velocity is required in the piping system than that maintained at the fan outlet, the area of the main pipe should be gradually increased. This is termed a **diverging cone** on the fan outlet, and if properly proportioned the loss due to the reduction in velocity at this point will be reduced to a minimum. Rules for the design of cone outlets and their effect in increasing the static pressure will be found given under "Diverging Nozzles in Air Ducts" on page 122.

The Relation Between Pressure, Velocity and Air Density in Fan Work

For low pressures, as in fan work, we may consider that the pressure varies inversely as the absolute temperature and directly as the barometric pressure. The volume of the same weight of air is directly and the weight of the same volume is inversely proportional to the absolute temperature. We will then have

$$\frac{p_0}{p}=\frac{T}{T_0} \text{ and } \frac{p_0}{p}=\frac{b_0}{b} \text{ or } p_0=p\times\frac{T}{T_0}\times\frac{b_0}{b} \qquad (77)$$

where p = pressure at absolute temp. T and barom. b.
p_0 = pressure at absolute temp. T_0 and barom. b_0.
T = absolute temp. of the air in deg. Fahr.
b = barometric pressure in in. of mercury.

Then in order to correct any given pressure reading **p**, at temperature **t** and barometer **b**, to the corresponding pressure for standard dry air at 70° F. and 29.92″ barom. we will have

$$p_0=p\times\frac{530}{460+t}\times\frac{b}{29.92}=\frac{0.075\ p}{W} \qquad (78)$$

Since at constant capacity and speed the power consumption will vary as the pressure, and the pressure varies as the density of the air, we will also have

$$\text{H.P.}=(\text{H.P.})_0\times\frac{460+t}{530}\times\frac{29.92}{b}=\frac{(\text{H.P.})_0\ W}{0.075} \qquad (80)$$

Thus, if a fan is to operate under some other condition than standard air, corrections can be made for pressure and horsepower by equations (78) and (80) respectively. For illustration see example 5, page 188.

In a centrifugal fan working under a constant orifice condition and at known air density, the theoretical velocity and pressure developed each bears a definite relation to the peripheral or tip velocity of the fan wheel. That is, the air velocity at the fan outlet and capacity is directly proportional to the peripheral velocity and fan speed, and the pressure developed varies directly as the square of the peripheral velocity and therefore as the square of the fan speed. Since the horsepower is proportional to the product of the pressure and capacity, the horsepower evidently varies as the cube of the fan speed. These combined relationships may be expressed by the following formula:

$$\frac{p}{p_o} = \frac{N^2 W}{N_0^2 W_0} \text{ and } \frac{H.P.}{(H.P.)_0} = \frac{N^3 W}{N_0^3 W_0} \qquad (81)$$

where N = revolutions per minute, and W = air density.

Laws of Fan Performance

In the selection and operation of fans, the size, speed, capacity, horsepower, and pressure each has a fixed and definite relation to the other, which may be expressed as follows:

For a given fan size, piping system, and air density—

1—Capacity varies directly as speed.
2—Velocity varies as speed or capacity.
3—Pressure varies as the square of the speed.
4—Speed and capacity vary as square root of the pressure.
5—Horsepower varies as cube of the speed or capacity.
6—Horsepower varies as $(\text{pressure})^{3/2}$

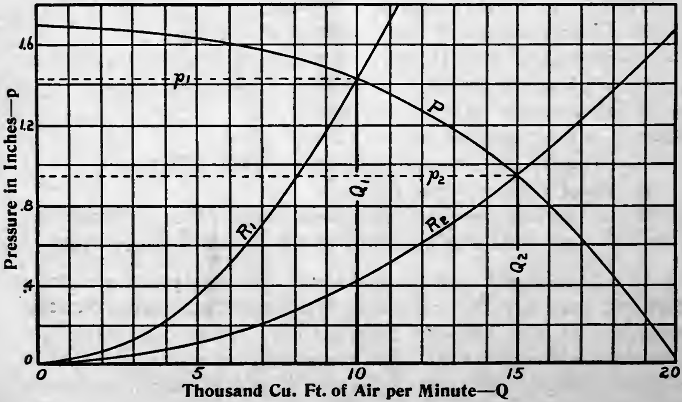
For a constant pressure and at rated capacity—

7—Capacity and horsepower vary as square of the size.
8—Speed varies inversely as size.
9—At constant pressure the speed, capacity and horsepower vary as the square root of the absolute temperature.

10—At constant capacity and speed, the horsepower and pressure will vary directly as the density of the air and approximately inversely as the absolute temperature. Thus increasing the temperature from 50° to 550° practically cuts the horsepower and pressure in half if the speed and capacity remain the same.

It has been shown that the pressure loss or resistance (p_s) of a given system of air passages varies as the square of the air velocity and therefore as the square of the air quantity, (Q). Also, since the pressure produced by a fan varies as the square of the speed (Law 3) under constant outlet conditions, it is evident that the air quantity delivered by the fan through a given system of air passages will vary directly as the speed, (Law 1). The relation between pressure loss and the air quantity passed through a given system may be termed the **coefficient of resistance** (R) of that system in the formula $p_s = R\ Q^2$, and $R = \frac{p_s}{Q^2}$ Also on page 125, it has been shown that each system has an equivalent or **blast-area** (A), where the pressure loss may also be expressed as $p_s = \left(\frac{Q}{V_0 \cdot A}\right)^2$ and where V_0 is the velocity corresponding to unit pressure. Hence $R = \left(\frac{1}{V_0 A}\right)^2$

If the coefficient of resistance or blast-area of a system to which a fan is applied should be changed while the fan is operated at constant speed, then the air delivery will undergo a change which is complicated by the fact that the fan pressure also changes with the quantity of air delivered, as shown by the pressure-capacity characteristic. This is best illustrated by the accompanying diagram. In the first case suppose we have a system whose coefficient of resistance is $R_1 = 142/10^{10}$ and in the second case the system is changed so the coefficient of



resistance is reduced to $R_2 = 42/10^{10}$. Curves R_1 and R_2 show how the pressure losses will vary with the air delivery in the respective cases, and curve P shows how the pressure produced by a 90-inch Planoidal exhauster at 330 R. P. M. varies as the air delivery. It is evident that the air delivery will be Q_1 for the first case and Q_2 for the second, with corresponding static pressures p_1 and p_2.

Selection of a Fan

It is well known and capable of demonstration in practice as well as in theory that of two straight blade fan wheels, the one having longer blades gives greater pressure, and that curving the blades forward in the direction of rotation increases the pressure, the converse also being true.

It is not a fact that a fan with forward curved blades is on that account any more efficient than one with radial blades; the two types have radically different characteristics, and each a field in which it excels; with the short forward curved blades good efficiency requires a greatly increased number as compared with the few blades of the radial type familiar in the steel plate fan.

In both types the need of careful design does not end with the proportions of the blades; the design of the scroll or housing, the area and position of the outlet and the diameter of the inlet are very important factors.

As explained under "Pressure Characteristics," the performance at other than rated capacity of the older style straight blade fan is entirely different from that of the curved blade multivane type. With the straight blade fan the pressure drops off rapidly when operated at overload, but increases when the fan is operated at less than rated capacity. In the case of the multiblade fans, the static pressure is greatest at normal load, and decreases at capacities either above or below this rated point.

Thus we see in the case of a system where a uniform air quantity is desired, whether for heating, ventilating, forced draft or for drying processes, the steel plate fan will come nearer giving this uniform quantity in spite of variations in resistance, throttling effect of closing dampers, and similar conditions.

On the other hand, it is sometimes very desirable to be able to throttle the capacity of a fan without increasing the pressure and velocity, as for instance, if one wing of a building is closed off and it is not convenient to change the speed of the fan, the steel plate fan would deliver an increased amount of air into the remaining part of the system on account of its increased pressure, while the multiblade fan would be more sensitive to the increased resistance and would show only a slight increase in velocity through the ducts which remain open.

In general, the multiblade fans, of which the Niagara Conoidal is a type, require less space than steel plate fans of equal capacity and efficiency. Another important advantage is the fact that the higher speeds of these multiblade fans make them more suitable for direct connection to motors, or at least give better pulley ratios than may be obtained with radial blade fans of equal efficiency.

After determining the style of fan to be used, there are two things to be considered in its selection. It must supply a definite amount of air per minute and it must supply this air at sufficient static pressure to overcome the friction loss of the system, which should be calculated or determined with reasonable accuracy. The performance of the fan under this condition is determined from the capacity tables.

Example 1. Assume that it is required to deliver 16500 cu. ft. air per minute against a static pressure of 0.95 in., and determine the size of Planoidal exhauster to be used, with the corresponding speed and horsepower. From the diagram on page 214 we see that at **rated capacity** the Planoidal fan gives a static pressure which is 79 per cent. of the rated total pressure. Then the total pressure corresponding to 0.95 in. static will be 1.20 in. From the table on page 208 we see that we may choose between a 90-inch fan operating over capacity or a 100-inch fan operating at less than rated capacity.

A 90-inch Planoidal fan has an outlet area of 7.10 sq. ft. (table page 208) so that the velocity through the outlet will be $16500 \div 7.1 = 2325$ feet per minute. From formula 21 on page 20 we have the pressure varies as the square of the velocity, and from formula 13 on page 18 the velocity for dry air at 70° F. corresponding to one inch pressure is 4005 feet per minute. The velocity head or velocity pressure at the outlet of the 90-inch fan corresponding to a velocity of 2325 feet per minute will then be

$$p_v = (2325 \div 4005)^2 = 0.337 \text{ in.}$$

The total pressure against which the 90-inch fan must operate will then be the sum of the static and velocity pressures, or 0.95 + 0.337 = 1.287 inches, and the ratio of static to velocity pressure will be 0.95 ÷ 0.337 = 2.82. Referring to the diagram on page 215, we find a point on the bottom scale corresponding to a ratio of static to velocity pressure of 2.82, and from the intersection of a vertical from this point with the curves above we may determine the relative performance of the fan from the scale on the left-hand edge of the chart. Thus we find that the fan will be operating at 108 per cent. of the rated capacity, and require 104.5 per cent. of the rated horsepower.

As already stated, the fan is required to deliver 16500 A. P. M.; so that 16500 ÷ 1.08 = 15300 A. P. M., the rated capacity of the fan at the speed used. From the table on page 208 we see that this fan will deliver 14890 A. P. M. at 334 R. P. M. and require 6.65 H. P. According to the relations given on page 179 the speed varies directly as the capacity and the power as the cube of the capacity. We will then have for a rated capacity of 15300 A. P. M.

$$\text{Actual speed} = 334\left(\frac{15300}{14890}\right) = 344 \text{ R. P. M.}$$

$$\text{Rated power} = 6.65\left(\frac{15300}{14890}\right)^3 = 7.22 \text{ H. P.}$$

But as already stated, when operating at 108 per cent. of the rated capacity, or 16500 A. P. M., this fan will require 104.5 per cent. of the rated power, so we will have

$$\text{Actual power} = 1.045 \times 7.22 = 7.55 \text{ H. P.}$$

The pressure developed will be 0.95 inch static and 1.287 inches total.

In case a 100-inch Planoidal fan should be selected for this service it will operate at less than the rated capacity, and the power required may be determined in the same manner as for the 90-inch fan. The outlet area of a 100-inch fan is 8.75 sq. ft. so the velocity at the outlet will be 16500 ÷ 8.75 = 1885 feet per minute and the corresponding velocity pressure will be $(1885 \div 4005)^2 = 0.221$ in. Since the fan is required to develop 0.95 in. static, the total pressure against which it will operate will be 0.95 + 0.221 = 1.171 in., and the ratio of static to velocity pressure will be 0.95 ÷ 0.221 = 4.30. From the diagram on page 215 we find that with a ratio of static to velocity pressure of 4.30 the fan will operate at 97 per cent. of the rated capacity and require 98.5 per cent. of the rated power.

As 16500 is to be 97 per cent. of the fan's rated capacity at the speed used, we have $16500 \div 0.97 = 17000$ A. P. M. as the rated capacity. From the table on page 208 we note that the 100-inch fan at 300 R. P. M. will deliver 18370 A. P. M. and require 8.20 H. P. To obtain a rated capacity of 17000 A. P. M. it will be necessary to reduce the speed and consequently the power to

$$\text{Speed} = 300\left(\frac{17000}{18370}\right) = 278 \text{ R. P. M.}$$

$$\text{Power} = 8.20\left(\frac{17000}{18370}\right)^3 = 6.50 \text{ H. P.}$$

As determined from the diagram, the power at 97 per cent. capacity will be 98.5 per cent. of the rated, so we will actually require

$$0.985 \times 6.50 = 6.40 \text{ H. P.}$$

Thus we see that while the first cost of the 100-inch fan will be greater, the cost for power will be less than with the 90-inch fan.

Example 2. A case frequently met in the application of fans is where the resistance against which the fan must operate is different from any of the pressures given in the fan capacity tables.

We will assume that 12000 A. P. M. is required at 0.20 in. static resistance. What size of fan shall be used and what will be the speed and horsepower? If a fan should be required to operate at rated capacity at a speed corresponding to the 0.20 in. resistance, we may select a Planoidal fan from the table on page 210. We note that the lowest pressure given in the table is ⅜ inch, but from the ratio given on page 179 we may determine the speed, capacity, and horsepower at 0.20 in. as follows: Since the capacity varies as the square root of the pressure, and we require 12000 A. P. M. at 0.20 in. the corresponding capacity at ⅜ in. will be $12000\ (0.375 \div 0.2)^{1/2} = 16450$ A. P. M.

We see from the table on page 210 that a 120-inch Planoidal exhauster at ⅜ inch static will have a rated capacity of 16030 A. P. M. at 152 R. P. M., and 2.62 H. P. We would use this size and operate it at slightly over the rated capacity to give 16450 A. P. M. at ⅜ inch or 12000 A. P. M. at 0.20 in. The rated speed of the 120-inch fan at 0.20 inch pressure will be $152\ (0.20 \div 0.375)^{1/2} = 111$ R. P. M. and the rated power will be $2.62\ \left(\frac{111}{152}\right)^3 = 1.02$ H. P. When operating at $16450 \div 16030 = 102$ per cent. of the rated capacity, the power required would be 1.08 H. P.

In order to determine the performance of a smaller fan under these conditions we will assume that a 100-inch Planoidal exhauster operating at over capacity is to be used. The outlet area of a 100-inch fan is 8.75 sq. ft. in area so that the velocity through the outlet will be $12000 \div 8.75 = 1370$ ft. per minute and the corresponding velocity pressure will be $(1370 \div 4005)^2 = 0.118$ in. The ratio of static to velocity pressure will then be $0.20 \div 0.118 = 1.7$, and from the diagram on page 215 we note that with this ratio the exhauster will operate at 118 per cent. of rated capacity and require 110 per cent. of the rated power.

If 12000 A. P. M. is 118 per cent. of the fan's rated capacity at the speed required to meet the assumed conditions, we will have $12000 \div 1.18 = 10150$ A. P. M. as the rated capacity. The table on page 210 does not give the speed and power required for 10150 A. P. M., but does give 182 R. P. M. and 1.81 H. P. for 11140 A. P. M. Since the speed varies directly and the power as the cube of the capacity we will have for 10150 A. P. M.,—$182\ (10150 \div 11140) = 162$ R. P. M., and $1.81\ (10150 \div 11140)^3 = 1.28$ H. P. as the rated speed and power. As already found from the diagram on page 215 with a ratio of static to velocity pressure of 1.7, the power required will be 110 per cent. of the rated, which gives us under the assumed conditions $1.28 \times 1.10 = 1.41$ H. P. when delivering 12000 A. P. M. against 0.20 in. static resistance at 162 R. P. M.

We see from the table on page 210 that a speed of 182 R. P. M. corresponds to a static pressure of 0.375 inch, and as the pressure varies as the square of the speed, the pressure for 162 R. P. M. will be $0.375\ (162 \div 182)^2 = 0.296$ in. That is, although the resistance of the system is only 0.2 in. and would call for a 120-inch fan, we may reduce the initial cost by using a 100-inch fan operating at a speed corresponding to approximately 0.3 in. with but 30 per cent. increase in the power consumption. Where the fan is to be direct connected to an engine and the exhaust steam used in the heating coils, this additional power is of little or no consideration.

Selection of a Niagara Conoidal Fan

Example 3. The Niagara Conoidal fan may be selected either from the **static pressure** tables on pages 232 to 273 or from the **total pressure** tables on pages 228 to 231. The total pressure tables, like the tables for Planoidal fans, give the performance of this fan at its point of rating only. The static pressure tables give the performance at other than the rated capacity, and give the speed and power required on both sides of the most efficient point. The tables on pages 274 and 275 indicate the efficiencies obtainable under different conditions of pressure and outlet velocity with these fans. Thus we see that there is one point in each pressure column at which the fan will give the highest efficiency. In the selection of these fans it may often be found expedient to operate at other than the most efficient point.

When selecting a fan for use in a public building it is advisable to use a velocity of about 1800 feet per minute through the fan outlet, with a maximum allowable velocity of 2200 for such work. For industrial installations, where higher duct velocities are the rule, outlet velocities up to 4000 may be used, without varying greatly from the most efficient performance.

To illustrate the use of the static pressure tables we will assume that it is required to deliver 17000 cu. ft. of air per minute against a pressure of one inch static. By an inspection of the corresponding tables, we find that we may use a No. 6 at 419 R. P. M., 6.59 H. P., and an outlet velocity of 3200 feet per minute; a No. 7 at 332 R. P. M., 5.19 H. P., and an outlet velocity of 2400 feet per minute or a No. 8 at 291 R. P. M., 4.86 H. P., and an outlet velocity of 1800 feet per minute. For use in a public building the No. 8 should be selected, but in case it is desirable to use higher duct velocities and absolute quietness of operation is not essential, either the No. 7 or No. 6 may be used.

Example 4. A common case of variable resistance in a fan system of heating and ventilating is where a fan is selected to supply a definite amount of air, and during the winter this air is drawn through the heater, but during the summer the damper to the by-pass is open so that the air may be drawn through both the heater and by-pass. As shown by the tables on pages 446 and 447, the resistance due to the heater will depend upon its depth and the velocity of the air through the clear area. From page 457 we see that under average conditions, we may assume two velocity heads lost due to the by-pass. Assuming a case where the heater is four sections deep with a velocity of 1000 feet per minute through the clear area, we find from the table on page 446 that the resistance will be 0.382 in. Allowing a loss of 0.24 in. static in the piping system, the fan will be required to operate against a static pressure of $0.382+0.240=0.622$ in. or $5/8$ in. This is under normal working conditions when the by-pass damper is closed.

We will first assume that a Planoidal exhauster is required to deliver 25000 A. P. M. under the above conditions. With this type of fan at rated capacity the static will be 79 per cent. of the total pressure, so that with a static resistance of 0.622 in. the corresponding total pressure will be $0.622 \div 0.79=0.787$ in. or approximately $3/4$ in. From the capacity table on page 210, we find that a 130-inch Planoidal exhauster at $5/8$ inch static pressure has a capacity of 24150 A. P. M. at 180 R. P. M. and will require 6.57 H. P. As this capacity is within a few per cent. of that required, it will be taken as the rated condition.

According to the data given on page 457 the resistance of a standard by-pass is approximately the same as that for four sections of Buffalo heater, so that in the case assumed when the by-pass damper is opened the effective area will be doubled. Since the loss due to the resistance varies as the square of the velocity and the velocity is to be reduced to $1/2$, the resistance for the same air quantity will be $(1/2)^2$ or $1/4$ of what it was when all the air passed through the heater. That is, with the by-pass damper open, the resistance at the heater will be one-fourth of 0.382 or 0.095 inch.

With the damper in the by-pass open the static resistance of the system will be reduced to $0.095+0.240=0.335$ in. providing the same air quantity is handled and it will be required to determine the results obtained under this new condition. The area of the outlet of the 130-inch fan is 14.85 sq. ft., so the velocity through the outlet under rated conditions would be $24600 \div 14.85=1685$ ft. per minute and the corresponding velocity pressure $(1685 \div 4005)^2=0.177$ in. With the by-pass damper open the static pressure based on the same air quantity is 0.335 in. and the ratio of static to velocity pressure will be $0.335 \div 0.177$ in. $=1.89$. From the diagram on page 215 we find that with this ratio the actual static pressure will be 65.5 per cent., the capacity 116.5 per cent. and the power 109 per cent. of the rated as given on page 187. That is, we will have

actual pressure $=0.622\times0.655=0.407$ in. static.
actual capacity $=24150\times1.165=28150$ A. P. M.
actual power $=6.57\times1.09=7.15$ H. P.

Correction for Temperature

Example 5. A case frequently met in selecting a fan is where the air to be handled is specified at some temperature other than the standard of the fan tables (70° F.). For instance, a "B" Volume Exhauster is required to handle 5500 cu. ft. of air per minute at a temperature of 600° F. against a pressure of two ounces. What size exhauster should be used and what will be the speed and horsepower? This fan is to handle the air at 600° while the capacity tables are based on air at 70°.

As explained on page 179, if the speed and capacity are kept constant the pressure and horsepower will vary inversely as the absolute temperature. Thus an increase in temperature from 70° to 600° doubles the absolute temperature $(1060\div530=2)$ and if we select a fan that will handle 5500 A. P. M. at 70° against four ounces it will have the same capacity at the same speed against two ounces when the temperature is 600° and the power will be half that given in the table for four ounces. From the capacity table of "B" Volume Exhausters on page 335 we find that the nearest size to that required will be No. 8, operating at 1420 R. P. M. and requiring $10.20\div2=5.1$ H. P.

Another example illustrating the effect of temperature would be to assume a fan is delivering 3500 A. P. M. at 1000° F. against 1½ oz. pressure with a speed of 920 R. P. M. What will be the speed and capacity of this fan at 500° and 2 oz. pressure?

The relative pressure of the air at 1000° and 500° is given by the ratio of the absolute temperature, or $1460\div960=1.52$. That is, if this fan handles the same volume of air at the same speed, due to the change in the temperature the pressure developed will be $1.5\times1.52=2.28$ oz. But this fan is required to operate at 2 oz. instead of 2.28 oz., which calls for a lower speed. We may see from page 179 that the speed and consequently the capacity will vary as the square root of the pressure, so the speed at 2 oz. will be $920\ (2\div2.28)^{1/2}=708$ R. P. M. and the capacity will be 3500 $(2 \div 2.28)^{1/2} = 2700$ A. P. M. Thus we see that this same fan will deliver 2700 A. P. M. at 500° against 2 oz. pressure when operated at 708 R. P. M.

Correction for Altitude

Example 6. The following example represents the calculations required to correct the fan performance to a sea-level (29.92 inches barometer) basis. Required a fan to handle 40000 A. P. M. against 0.5 in. static pressure at an altitude of 5000 feet with a temperature of 70°. As the fan tables are based on air at sea-level, we will have to reduce the above specified pressure to a sea-level basis. From the diagram on page 25 we note that the relative pressure for this altitude is 0.835, so that a sea-level pressure corresponding to a pressure of 0.5 in. at 5000 altitude is $0.5 \div 0.835 = 0.6$ in., or approximately ⅝ in. The horsepower required to operate the fan will be 83.5 per cent. of the rated horsepower as given in the capacity tables for ⅝ in. static.

We find from the table of Niagara Conoidal capacities on page 248 that a double No. 8 fan with an outlet velocity of 2200 feet per minute would answer the requirement at ⅝ in. at 238 R. P. M. and 8.66 H. P. At 5,000 altitude the power consumption will be $8.66 \times 0.835 = 7.23$ H. P.

Another example illustrating the correction for altitude would be to require an induced draft system for 1600 boiler H. P., at an altitude of 5200 feet with flue gases at 550° F. and a static pressure of one inch required. From the diagram on page 25 we find that the factor for 5200 altitude is 0.83. The corresponding pressure at sea-level will then be $1 \div 0.83 = 1.20$ in.

From the table on page 325 we find that a 150-inch Planoidal exhauster operating at 305 R. P. M. will have a capacity of 63110 A. P. M. at 1.25 in. static with a temperature of 550° and require 34.0 H. P. With an allowance of 32.4 A. P. M. at this temperature per boiler H. P. this fan will be capable of supplying draft for 1950 H. P. of boilers at sea-level. The air required per boiler horsepower at an altitude of 5200 feet will be $32.4 \div 0.83 = 39.0$ A. P. M. so that the draft capacity of this fan at 5200 altitude will be only $63110 \div 39.0 = 1620$ or $1950 \times 0.83 = 1620$ boiler H. P. The power requirements at 5200 altitude will be $34.0 \times 0.83 = 28.2$ H. P.

SECTION II

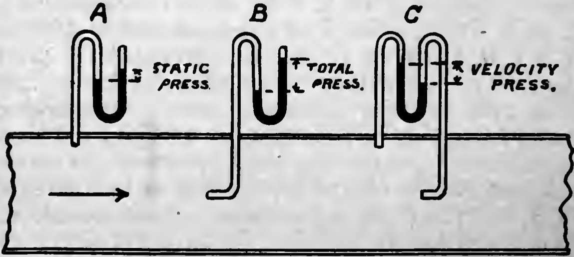
FAN TESTING

It is frequently necessary to make a test on a fan installation in order to determine the quantity of air being delivered. There are several methods of making this determination, depending on the degree of accuracy desired, the object of the test, or the conditions under which the system is installed. The velocity and quantity of air delivered by a fan or flowing through a duct may be found by means of a pitot tube, an anemometer, a converging nozzle, an orifice, or a short length of pipe. Each method may be especially applicable under various conditions and a selection should depend on the object and accuracy desired.

The most accurate method for ordinary work is to use the pitot tube, either in an air duct or in connection with a converging nozzle attached to the fan outlet. The anemometer is especially useful in determining the velocity and quantity of air entering a room in order to properly proportion the air distribution in an indirect heating or ventilating system. An orifice or a short length of pipe is frequently used in connection with test work, where a permanent piece of apparatus is desired.

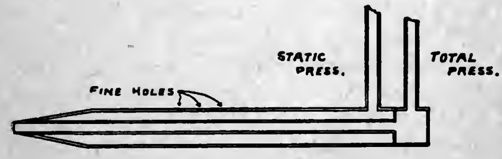
The Pitot Tube

The pitot tube is an instrument used for making velocity measurements of a current of air, the principle of its action being shown by the accompanying diagram. As already explained,



when there exists a flow of air due to a certain pressure, a part of this pressure, termed the velocity head, is transformed into velocity, while the balance, termed pressure of static head, serves to produce pressure. If a bent tube with an open end be inserted in an air duct, as at B in figure on page 190, with the open end facing the air current, a pressure due to both the velocity and static head will be produced in this tube. This is the total or dynamic head, and the amount can be read on an attached gauge or manometer tube. If, instead of a bent tube, a straight tube be inserted as at A, the difference in levels in the manometer tube will indicate the static head or pressure. The velocity head or pressure may then be determined by subtracting the static from the total manometer reading.

The pitot tube as ordinarily used is an instrument combining the tubes just described, as shown at C, the outer ends being connected to the two legs of the same manometer. By this means the subtraction is made automatically and the difference as shown by the gauge is due to velocity pressure only. These tubes are usually combined in some form as shown in the following figure.



Care should be taken to have all of the connections made tight, especially on the static side, as a very slight leak here will cause considerable error. The small holes as shown above in the static tube should be about 0.02 in. in diameter.

The greatest difficulty to be encountered in air measurements is in obtaining accurate static pressure readings. Many different forms of static tubes have been used, with varying degrees of accuracy. Some of the more common forms are shown on page 192. Charles H. Treat in a paper on "Measurements of Air in Fan Work"* gives the results of his efforts to check the accuracy of some of these forms. He found that tube D was fairly accurate so long as it was set exactly parallel to the air flow, but the open tube E held at right angles to the air flow gave readings as much

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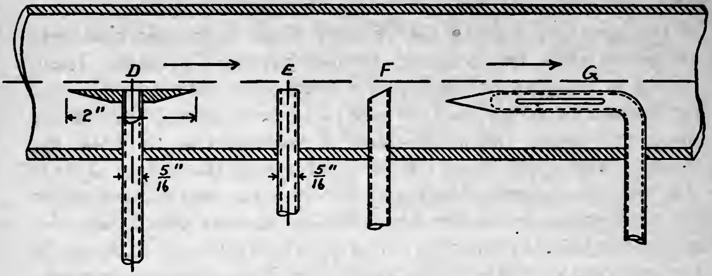
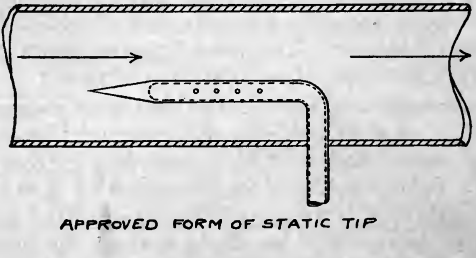
* Am. Soc. Mech. Engrs., Dec., 1912.



DIFFERENT FORMS OF STATIC TIPS.

as 50 per cent. too low. The total pressure, or impact tube, as shown in the sketch representing a pitot tube, will give practically true readings, so that if the static readings are too low the corresponding velocity pressure readings will be too great.

The Gebhardt tube uses a static tip which has the end beveled as at F, in order to avoid the suction of the air flow across the end of the tube, but Prof. Gebhardt states that further experiments are necessary to show whether any fixed angle is applicable to all velocities. A static tube as shown at G is frequently used, having slots on the sides of the tube, the Taylor pitot tube being an adaptation of this form. Mr. Treat found that a slot ⅝ in. long and 0.01 in. or less wide in a ¼-inch tube gave good results, but it is advisable to cover these slots with a piece of fine mesh wire cloth.



APPROVED FORM OF STATIC TIP

The static tube here shown is the most approved form, and is the one recommended by the A. S. M. E. for fan testing work. It may be combined with the impact tube to form a pitot tube as already shown. Charles H. Treat found that a static tube of this form with clean holes 0.02 in. in diameter in ¼-inch tubing 1/32 in. thick, gave static readings accurate to within less than one per cent. of the pressure due to the velocity. A hole 1/16 in. in diameter in this tube gave readings considerably off, while a 2-in. slot 1/16 in. wide gave velocity readings approximately 10 per cent. too low. Covering the slot with wire cloth improved the results obtained. A ⅝-in. slot 0.01 in. or less in width gave fairly accurate results. The tube of the above standard form gave fairly accurate results even though as much as five degrees out of parallel with the air flow.

A very complete series of tests have been made by W. C. Rowse* in which he compared different forms of pitot tubes with the readings of a Thomas electric meter. The author used a pitot tube similar in shape to the one already described, and found that "of the various forms of static openings in the pitot tube itself, very small holes in a perfectly smooth surface give the most accurate results. Slots give erroneous static pressures and beveled-ended tubes for obtaining static pressures are not reliable."

A convenient form of gauge for use with low pressure is the ordinary Ellison differential draft gauge. Mineral seal oil should be used in the Ellison gauge, but it is so graduated that it gives the pressure directly in inches of water, without any correction. The mineral seal oil as ordinarily used for this purpose has a specific gravity of 0.8284.

The theory of the pitot tube is thoroughly discussed by Frank H. Kneeland, together with a study of some of the different forms, in a paper recently read before the American Society of Mechanical Engineers.**

Having determined the velocity head as above explained, the actual velocity may be calculated approximately by means of the formula

$$V = 1096.5\sqrt{\frac{p}{W}} \qquad (84)$$

where V = velocity of air in ft. per min.
p = pressure in in. of water.
W = weight of air in lbs. per cu. ft.

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*"Pitot Tubes for Gas Measurement" Am. Soc. Mech. Engrs., Sept., 1913.

**"Some experiences with pitot tube on high and low air velocities" Am. Soc. Mech. Engrs., Dec., 1911.

The relationships between velocity and pressure will be found on page 16, from which we see that if we have dry air at 70° F. and 29.92 inches barometer, we will have $W = 0.07494$, hence the approximate formula (84) becomes

$$V = 4005\sqrt{p}$$

Where the pressure p is expressed in inches of water, or

$$V = 5273\sqrt{p}$$

where p is expressed in ounces per square inch.

The above formulae are only accurate for low pressures, and should not be used for over 10 inches of water. For more accurate work or for high pressures the following formulae should be used. As a matter of ready reference the table of velocity for various pressures as given on page 21 will be found convenient.

Capt. D. W. Taylor in a paper entitled "Experiments with Ventilating Fans and Pipes"* gives the following exact formula for the pitot tube:

$$\frac{V_1^2 - V_2^2}{2g} = \frac{y}{y-1} \times \frac{p_2}{W}\left[1 - \left(\frac{p_1}{p_2}\right)^{\frac{y-1}{y}}\right] \qquad (85)$$

where V_1 = velocity in ft. per second at a point where the pressure = p_1 in lbs. per sq. ft.

p_2 = pressure in lbs. per sq. ft. at any other point.

V_2 = velocity in ft. per second.

W = weight of air in lbs. per cu. ft. where press. = p_2

y = ratio between specific heats of air under constant pressure and constant volume = 1.408.

g = acceleration due to gravity in ft. per second.

The above formula has been presented in a simplified form by Frank H. Kneeland** as follows:

$$V_1 = 4046.16\sqrt{\frac{p_2 - p_1}{W}(1 - 0.355k + 0.202k_2 - 0.137k_3)} \qquad (86)$$

where

$$k = \left(\frac{p_2}{p_1} - 1\right)$$

The values given above are for a temperature of 70° F., a barometric pressure of 29.92 inches, and a humidity of 70 per cent.

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*Society of Naval Arch. and Marine Engrs., 1905, p. 35.

**"Some experiences with pitot tube on high and low air velocities" Am. Soc. Mech. Engrs., Dec., 1911.

From the preceding it is seen that the velocity at 70° F. and 29.92 inches barometer due to one-inch pressure is 4005 feet per minute and the velocity at any other pressure may be determined from the above relation. That is, the velocity varies as the square root of the pressure. For any other temperatures the velocity may be found by inserting the proper values of W in formula (84), or from the ratio of the absolute temperatures or barometric pressure, since at constant pressure the velocity will vary directly as the square root of the absolute temperatures and inversely as the square root of the barometric pressure.

These formulae may be considered sufficiently accurate for ordinary velocities, say up to 6000 feet per minute. Above that velocity and for very accurate work, various corrections should be made. These corrections, based on the experiments of Capt. D. W. Taylor are discussed by Mr. Kneeland in the paper already referred to.

Use of the Pitot Tube in an Air Duct

For fan testing or in ventilation work the pitot tube may be used to determine the velocity, and hence the quantity, of air flowing through a duct or pipe. The tube should be inserted at a point where the duct is straight and the flow undisturbed. In testing a fan the pitot tube should be placed from 10 to 20 diameters from the fan outlet with the point directly facing the blast. The air pipe should be the same diameter as the fan outlet.

The velocity pressure as shown with the tube in the center of the duct will be higher than the average, and will vary at different points from the center to the sides of the duct. In order to obtain the true or average pressure it is necessary to multiply the velocity pressure reading obtained at the center by the proper coefficient. Various authorities give a coefficient of from 0.81 to 0.82 for circular pipes, by which the velocity pressure readings taken at the center of the pipe should be multiplied to obtain the corrected average pressure. Consequently the velocity based on the observed pressure readings may be multiplied by the coefficient 0.91 to obtain the corrected average velocity.

For more accurate work it is better to make a traverse of the pipe and either determine the coefficient for the case in question or take the average of all of the readings. Where the duct is rectangular it may be divided into a number of small squares or rectangles and a reading taken in the center of each. Then the average of all of the velocities corresponding to these pressures will give the true velocity in the duct. In case the pipe is round its area should be divided into a number of concentric zones or rings of equal area, and four readings taken in each area, readings being taken horizontally and vertically across the pipe.

The position of each successive point may be found by dividing each ring into two equal areas and adding one of these to the sum of the preceding areas. The radius of this resulting area will locate the desired point.

Expressed by means of a series of formulae, these points may be found as follows:

$$R_1 = \sqrt{\frac{a}{6.2832}} \tag{87}$$

$$R_2 = \sqrt{\frac{a + (a \div 2)}{3.1416}} \tag{88}$$

$$R_3 = \sqrt{\frac{2a + (a \div 2)}{3.1416}} \tag{89}$$

$$R_4 = \sqrt{\frac{3a + (a \div 2)}{3.1416}} \tag{90}$$

Where R_1, R_2, etc., = the distance from the center to the points where the readings should be taken in each successive ring.

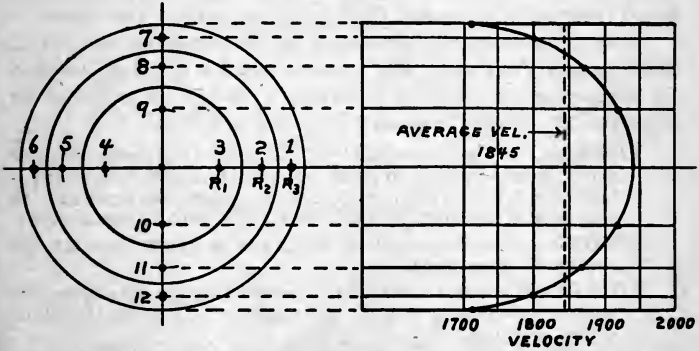
a = the area of each zone or ring.

PIPE TRAVERSE FOR PITOT TUBE READINGS

Distance From Center of Pipe to Point of Reading in Per Cent. of Pipe Diameter

No. of Equal Areas in Traverse	No. of Readings	First R_1	Second R_2	Third R_3	Fourth R_4	Fifth R_5	Sixth R_6	Seventh R_7	Eighth R_8
3	12	20.4	35.3	45.5					
4	16	17.7	30.5	39.4	46.6				
5	20	15.5	27.2	35.3	41.7	47.4			
6	24	14.5	25.0	32.3	38.2	43.3	47.9		
7	28	13.4	23.1	29.9	35.3	40.1	44.3	48.2	
8	32	12.5	21.6	28.0	33.2	37.6	41.5	45.1	48.4

The location of the points on a traverse where readings should be taken are shown in the accompanying sketch. The table on page 196 is based on formulae (87) to (90) for laying out a traverse and will be found very convenient for that purpose. As an example of its use we will assume that a traverse is to be made of a 24-inch pipe, twelve readings to be taken. One reading will be taken at 0.204×24″=4.9″ from the center of the pipe; one at 0.353×24″=8.46″ from the center, and one at 0.455×24″= 10.92″ from the center.



An example of laying out a traverse and finding the average velocity through a round duct is illustrated in the accompanying figure drawn from test results. Twelve readings were taken as shown on the diagram, the points being laid out according to the table on page 196. The velocities were then computed for each point and the average velocity for each area plotted as shown, these points on the lower and upper half of the plot being the same. A curve drawn through these points indicates the velocity at the edge and at the center of the pipe, and these points should be used in calculating the average velocity.

The Anemometer

The anemometer is used in many cases where the velocity of the air is low or extreme accuracy is not required. It is more frequently used to determine the velocity of the air leaving a register or air vent than for testing a fan, although it may be used for either purpose. An anemometer should be frequently calibrated, and when used in a current of hot air the bearings of the instrument are liable to become dry and the readings affected by friction. Such an instrument may vary as much as 10 or 20 per cent. from the true reading.

The space over which the velocity is to be measured should be divided into a considerable number of smaller squares and the velocity readings taken before each square; the average of these readings gives the air velocity in the duct or pipe. Another method frequently used when taking readings before a register or outlet in wall is to take a series of readings along the two diagonals of the openings, each reading being taken during an equal interval of time and similar distances from the center.

A special committee, appointed by the American Society of Heating and Ventilating Engineers to draft a standard method for measuring air velocities at supply openings by means of an anemometer, reported January 23, 1913, as follows:

FIRST:—The openings shall be divided into equal rectangular areas, no side of which shall be over 10 inches long excepting where this would require more than ten readings, in which case the opening shall be divided into 12 equal areas.

SECOND:—Readings are to be taken in every case at the center of every area.

THIRD:—Readings are to be one-half minute duration, the anemometer being held at the register base or in the plane of the opening.

FOURTH:—Where the diffusers are used, a total area is to be computed on the basis of the periphery of the diffuser.

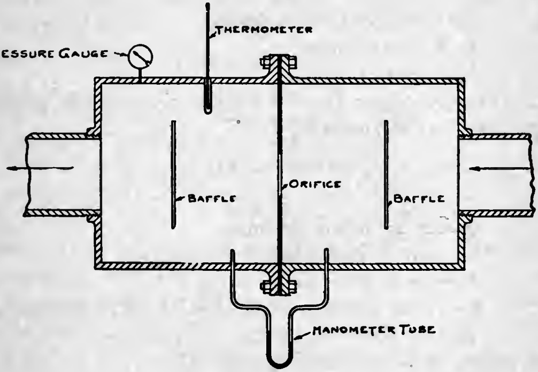
FIFTH:—The average of the readings are to be considered as the average velocity at the opening. Where negative velocities are found, they are to be deducted in arriving at the average velocity.

SIXTH:—In computing volume, the net area of the opening is to be taken, the volume to be considered as the product of the average velocity and the net area of the opening. In case the anemometer is held two inches from the register face, no deduction should be made for the register mesh.

The Orifice

An orifice in connection with some form of testing apparatus is frequently used for fan testing work, usually as a part of a permanent testing plant where the air is blown into a large air-tight box and escapes from the box through an orifice. A coefficient of 0.600 applied to the velocity is commonly used with this apparatus. Professor Durley describes in Vol. 27 of the Trans. A. S. M. E. a series of tests where various sized orifices were attached to the end of a gauging box and a set of coefficients determined for the different conditions.

The orifice may also be used for measuring the air delivery in connection with compressed air systems, where the air is under a pressure of several atmospheres. A convenient form of apparatus for such use is here shown, in which the air passes through an enlargement in which the orifice is fastened.



As shown in the sketch, baffles should be provided on each side of the orifice. The pressure, P, should be taken on the leaving side of the chamber, the temperature being taken on either side. The drop in pressure, p_v, between the two sides of the orifice may be measured either in inches of water or of mercury by means of a manometer connected to the two sides of the chamber. The inner ends of these tubes should enter well between the baffle and the orifice plate. Different sizes of orifices may be used in the same apparatus, according to the pressure carried, diaphragms with openings from 1 to 2½ inches in diameter being a suitable range for a chamber having a 4-inch inlet.

The equation for this apparatus would then be

$$Q = 100A\sqrt{P\,T\,p_v} \qquad (91)$$

where Q = cu. ft. free air per min.
A = area of orifice in sq. ft.
P = absolute pressure in lbs. per sq. in.
T = absolute temperature deg. F.
p_v = drop in pressure in inches of mercury.

Orifice at End of Pipe

An orifice may be used on the end of a length of pipe for measuring the air discharged, as shown by Fig. **a.** The coefficient for such a case is

$$C = \frac{0.60}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \qquad (92)$$

where
C = coefficient of discharge.
A_1 = area of pipe.
A_2 = area of orifice.

The quantity of air delivered by a given static pressure in the pipe may be determined by

$$Q = 1096.5\ C\ A_2 \sqrt{\frac{p}{W}} \qquad (93)$$

where
Q = cu. ft. of air per min.
C = above coefficient of discharge.
A_2 = area of orifice in sq. ft.
p = static pressure in inches of water in main pipe.
W = weight of air in lbs. per cu. ft.

For values of W see table on page 17.

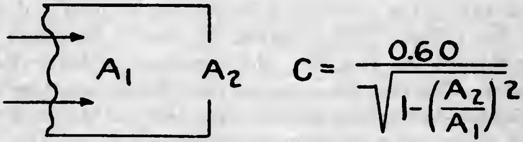


FIG. a ORIFICE AT END OF PIPE.

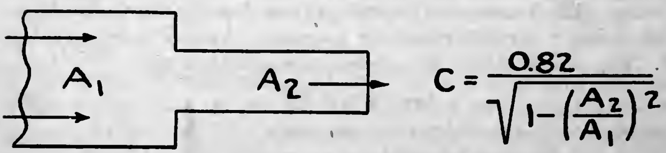


FIG. b SHORT PIPE ATTACHED TO END OF LARGER PIPE.

The orifice may be replaced by a short length of pipe as in Fig. **b**, in which case the coefficient of discharge becomes

$$C = \frac{0.82}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \qquad (94)$$

The above coefficients have been verified experimentally and found to be adapted to measurements of air under low pressures.

Short Length of Pipe

A short length of pipe (preferably three diameters long) connected to a box or plenum chamber into which the fan discharges is frequently used instead of an orifice for fan testing, and for several reasons makes a better arrangement. It is used on the outlet of a tight box into which the air is blown by the fan, the air escaping through the short pipe. The static pressure in the box is carefully noted, it being a measure of the fan performance. The box leakage, if any, should be determined.

A coefficient of discharge of 0.825 should be applied to the area of the short pipe to determine the true effective area, or to the velocity of the air. If required, a traverse may be made of the pipe with a pitot tube and the coefficient determined for any special cases.

The quantity of air discharged may be determined by means of the formula:

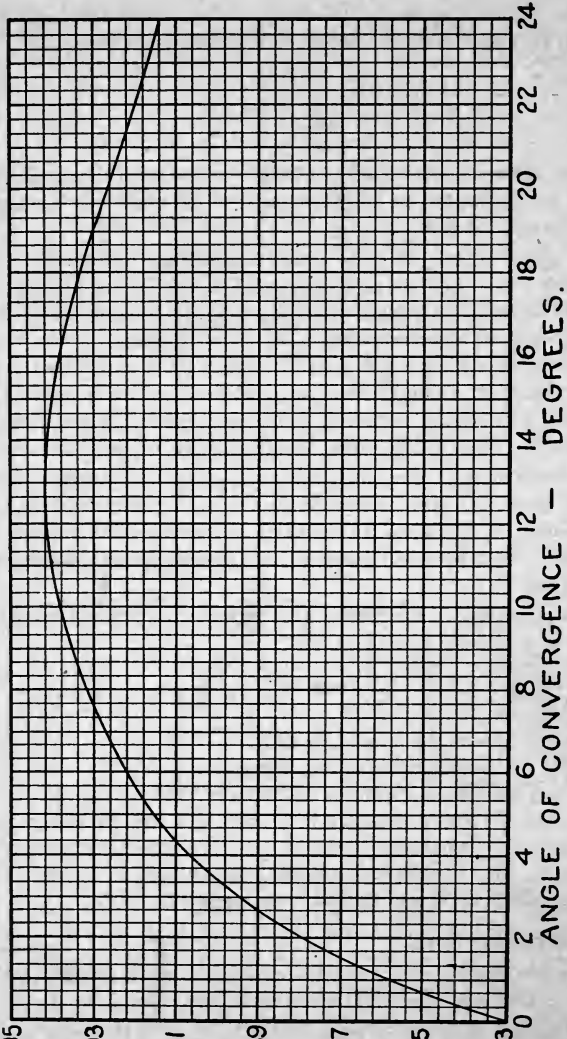
$$Q = 1096.5\ C\ A \sqrt{\frac{p}{W}}$$

where Q = cu. ft. of air per min.
C = coefficient of discharge.
A = area of pipe in sq. ft.
p = static pressure in inches of water in the plenum chamber.
W = weight of air in lbs. per cu. ft.

For values of W see the table on page 17.

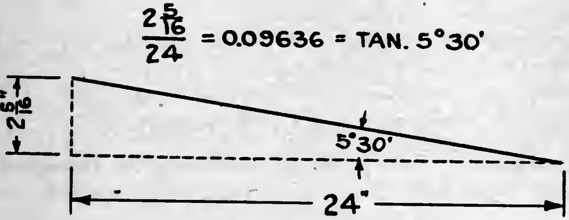
The Converging Nozzle

A method frequently used in commercial work for fan testing, or for testing a special fan before its installation, is by means of a converging nozzle attached directly to the fan outlet. The pressure produced by the velocity of the air is measured at the point of discharge by means of a pitot tube, placed at the center



Coefficient of Discharge for Converging Nozzles When Used for Fan Tests of the nozzle outlet. Proper correction must be made according to the accompanying curve of coefficients of discharge for converging nozzles. This curve is based on coefficients as given in Merriman's Treatise on Hydraulics.

To illustrate the use of the converging nozzle, we will take the case of a 40-inch planing-mill exhauster at 1780 R. P. M., blowing through a converging nozzle having the inlet and outlet ends 14 and 9⅜ inches square, with sides sloping at an angle as here shown. The outlet area of the nozzle would be 0.61 sq. ft.



The angle of convergence of the cone outlet would be 11° and from the curve on page 202 the corresponding coefficient is 0.94.

The pressure on the fan will be taken at 3 inches; and the corresponding velocity will be $4005\sqrt{3} = 6950$ ft. per min. At this velocity through the outlet of 0.61 sq. ft. the fan would handle 4230 A. P. M., but the actual quantity handled will be

$$4230 \times 0.94 = 3980 \text{ A. P. M.}$$

Coefficients of Discharge for Air Measurements

Various coefficients are used in the calculation of fan performance or in air measurements, and their derivation and application will be found fully discussed under their proper heading. The following summary is given merely as a matter of convenience, but the factors should not be used without first having an intelligent understanding of their proper application. In case of special requirements it may be found necessary to modify the given coefficient accordingly.

Coefficients of Discharge for Air Measurements

Coefficient for sharp orifice in thin plate	0.600
Coefficient for orifice at end of pipe	$\frac{0.60}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}}$
Coef. for short pipe attached to end of larger pipe For explanation see page 201.	$\frac{0.82}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}}$
Coefficient for short length of pipe (blowing from plenum chamber)	0.82
Coefficient for short pipe on outlet of fan (see page 201)	0.95
Coefficient for round pipe (pitot tube in center)	0.91
Coefficient for converging nozzle (see curve page 202).	
Coefficient for diverging nozzle (see curve page 223).	

The quantity of air to be measured may be calculated by means of the formula

$$Q = 1096.5\, C\, A \sqrt{\frac{p}{W}}$$

where Q = cu. ft. air per min.
C = coefficient of discharge.
A = area of pipe in sq. ft.
p = static pressure in inches causing flow of air.
W = weight of air in lbs. per cu. ft.

For values of the weight of air in pounds per cubic foot for various atmospheric conditions see the table on page 17.

The coefficients given above are to be applied to **velocity, capacity,** or to the **effective area** of pipe or outlet. The proper coefficients to be applied to the **pressure readings** will be the square of the ones given above. Thus the coefficients for pressure in a round pipe varies from 0.81 to 0.82. These are to be applied to the pressure readings of the pitot tube when taken at the center of the pipe or duct. This coefficient for round pipes is based on test data, but should be decreased for pipes below 12 inches in diameter and increased by a small amount for pipes above 24 inches in diameter.

SECTION III

FAN CAPACITIES

The following chapter gives the capacity tables and performance curves for the various styles of Buffalo fans. These are divided into the following divisions: Planoidal Exhausters, Planoidal Blowers, Niagara Conoidal Fans, Turbo-Conoidal Fans, Induced Draft Tables, Miscellaneous fans and blowers. In each case the corresponding performance curves follow the capacity tables. The tables show the rated speed, capacity, and horsepower for fans operating at the different pressures stated, with the exception of the static pressure tables of the Niagara and Turbo-Conoidal fans, which give the performance at other than the rated point.

Use of Performance Curves

In connection with the steel plate and multivane fans, as well as several other styles, are shown relative performance curves, based on actual tests. The scale on the lower edge of each diagram reads per cent. of rated capacity, while the left-hand margin reads directly in per cent. The capacity curves show the relative horsepower, efficiency and pressure at any capacity in per cent. of their respective values at rated capacity. Thus we see from the diagram on page 214 of Planoidal Exhausters, if the fan is operated at say 80 per cent. of the rated capacity, the horsepower required will be 87.5 per cent. and the total pressure 116 per cent. of the rated values as given in the capacity tables. The efficiency will be 6 per cent. greater than at rated capacity.

The use of these diagrams for the analysis of fan performances has been fully covered under the subject of "Fans" (Part IV, Section I) and their application in the selection of a fan may be found on page 182, together with the practical examples explaining the various calculations involved. The relations between static, velocity, and total pressure will be found on page 177.

Combination Fan, Heater and Engine Tables

A series of tables giving combinations of fan, heater, and engine for various duties will be found in Part IV, Section VIII, following the examples on "The Selection of Apparatus." The air capacities given are based on the assumption that an average maximum value for the total pressure, in case of an installation in a public building such as a school or theatre, will be about one inch, and for industrial installations about two inches. A series of heater sizes is given for each fan, and a selection should be made on the basis of allowable velocity through the clear area. For public buildings the larger sizes should be used, and for industrial installations, the smaller. The depth of the heater will depend on the temperature range to be cared for, and may be determined from the heater tables on pages 418 to 431. The low pressure engines were selected on the assumption of 20 to 25 pounds and the high pressure engines on 80 to 100 pounds steam pressure at the throttle. The engines are all suitable for direct connection to the given size of fan.

Planoidal Type "L" Fan Direct Connected to Class "I" Vertical Cylinder Below Shaft Engine

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS

Temperature of 70° F., 29.92 Inches Barometer

Size	Diam. Blast-Wheel	Area of Outlet Sq. Ft.	½" Total Press. or 0.288 Oz.			⅝" Total Press. or 0.360 Oz.			¾" Total Press. or 0.433 Oz.			⅞" Total Press. or 0.505 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	19¼"	0.77	620	1030	0.18	693	1150	0.25	760	1260	0.32	819	1350	0.41
35	22¼"	1.04	532	1400	0.24	594	1560	0.34	651	1710	0.44	702	1840	0.55
40	25¾"	1.36	465	1820	0.31	520	2040	0.44	570	2230	0.58	614	2410	0.72
45	29⅞"	1.75	414	2010	0.40	462	2580	0.55	506	2820	0.73	546	3050	0.91
50	32⅛"	2.16	372	2850	0.49	415	3180	0.68	456	3490	0.90	492	3760	1.13
55	35⅜"	2.61	338	3440	0.59	378	3850	0.83	414	4220	1.09	447	4550	1.37
60	38½"	3.13	310	4100	0.71	347	4580	0.98	380	5020	1.30	410	5410	1.63
70	45"	4.26	266	5580	0.96	297	6230	1.34	326	6830	1.76	351	7370	2.21
80	51⅜"	5.54	233	7290	1.25	260	8140	1.75	285	8920	2.30	307	9620	2.89
90	57⅞"	7.10	207	9220	1.59	231	10270	2.21	253	11290	2.92	273	12180	3.66
100	64¼"	8.75	186	11380	1.96	208	12720	2.73	228	13940	3.60	246	15040	4.51
110	70¾"	10.57	169	13770	2.37	189	15390	3.30	207	16870	4.36	224	18190	5.46
120	77¼"	13.00	155	16390	2.82	173	18320	3.90	190	20080	5.18	205	21650	6.50
130	83½"	14.85	143	19240	3.31	160	21500	4.61	175	23560	6.08	189	25410	7.63
140	90"	17.20	133	22310	3.84	149	24930	5.35	163	27330	7.05	176	29480	8.84
150	96½"	19.70	124	25610	4.41	139	28620	6.14	152	31370	8.10	164	33830	10.2
160	103"	22.40	116	29140	5.01	130	32560	6.99	142	35690	9.21	154	38500	11.6
170	109¼"	25.40	110	32900	5.66	122	36760	7.89	134	40290	10.4	145	43460	13.0
180	115¾"	28.50	103	36880	6.34	116	41200	8.84	127	45170	11.7	137	48720	14.6
190	122¼"	31.70	98	41100	7.07	110	45930	9.86	120	50330	12.9	129	54300	16.3
200	128½"	35.30	93	45540	7.83	104	50880	10.9	114	55760	14.4	123	60150	18.1
210	135"	38.7	89	50200	8.64	99	56100	12.0	109	61480	15.9	117	66310	19.9
220	141½"	42.2	85	55100	9.48	95	61550	13.2	104	67480	17.4	112	72780	21.9
230	148"	46.5	81	60210	10.4	90	67280	14.4	99	73750	19.0	107	79540	23.9

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS

Temperature of 70° F., 29.92 Inches Barometer

Size	Diam. Blast-Wheel	Area of Outlet Sq. Ft.	1" Total Press. or 0.577 Oz.			1¼" Total Press. or 0.721 Oz.			1½" Total Press. or 0.865 Oz.			1¾" Total Press. or 1.010 Oz.		
			R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	19¼"	0.77	877	1450	0.50	981	1620	0.70	1074	1770	0.91	1160	1920	1.15
35	22½"	1.04	752	1970	0.68	840	2200	0.95	921	2410	1.25	995	2610	1.57
40	25¾"	1.36	658	2580	0.89	735	2880	1.24	806	3150	1.63	870	3410	2.05
45	29⅞"	1.75	585	3260	1.12	654	3640	1.57	716	3990	2.06	774	4310	2.60
50	32⅛"	2.16	526	4030	1.38	588	4500	1.94	645	4930	2.54	696	5330	3.21
55	35⅜"	2.61	478	4870	1.68	535	5440	2.34	586	5960	3.08	633	6440	3.88
60	38½"	3.13	439	5800	1.99	490	6480	2.79	537	7100	3.66	580	7670	4.62
70	45"	4.26	376	7890	2.71	420	8820	3.79	460	9650	4.99	497	10450	6.28
80	51⅜"	5.54	329	10300	3.54	368	11520	4.95	403	12620	6.51	435	13630	8.21
90	57⅞"	7.10	292	13040	4.49	327	14580	6.27	358	15970	8.24	387	17250	10.4
100	64¼"	8.75	263	16100	5.54	294	18000	7.74	322	19720	10.2	348	21300	12.8
110	70¾"	10.57	239	19480	6.70	268	21780	9.36	293	23860	12.3	316	25770	15.5
120	77¼"	13.00	219	23180	7.97	245	25920	11.2	269	28390	14.7	290	30670	18.5
130	83½"	14.85	202	27210	9.36	226	30420	13.1	248	33320	17.2	268	36000	21.7
140	90"	17.20	188	31560	10.9	210	35280	15.2	230	38650	19.9	249	41750	25.1
150	96½"	19.70	175	36230	12.5	196	40500	17.4	215	44360	22.9	232	47930	28.9
160	103"	22.40	164	41220	14.2	184	46080	19.8	201	50470	26.0	218	54510	32.8
170	109¼"	25.40	155	46530	16.0	173	52020	22.4	190	56980	29.4	205	61560	37.0
180	115¾"	28.50	146	52160	17.9	164	58320	25.1	179	63880	33.0	194	69000	41.5
190	122¼"	31.70	139	58120	20.0	155	64980	27.9	170	71180	36.7	183	76900	46.3
200	128½"	35.30	132	64400	22.2	147	72000	31.0	161	78870	40.7	174	85200	51.3
210	135"	38.7	125	71000	24.4	140	79380	34.1	154	86950	44.9	166	93930	56.5
220	141½"	42.2	120	77920	26.8	134	87120	37.5	147	95430	49.2	158	103080	62.1
230	148"	46.5	114	85170	29.3	128	95220	40.9	140	104300	53.8	151	112680	67.8

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS

Temperature of 70° F., 29.92 Inches Barometer

Size	Diam. Blast-Wheel	Area of Outlet Sq. Ft.	2" Total Press. or 1.154 Oz.			2½" Total Press. or 1.442 Oz.			3" Total Press. or 1.734 Oz.			3½" Total Press. or 2.019 Oz.		
			R. M. P.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	19¼"	0.77	1240	2050	1.41	1387	2290	1.97	1519	2510	2.59	1641	2710	3.26
35	22½"	1.04	1064	2790	1.92	1189	3120	2.68	1302	3420	3.52	1406	3690	4.44
40	25¾"	1.36	930	3630	2.51	1040	4070	3.50	1139	4460	4.60	1230	4820	5.80
45	29⅞"	1.75	827	4610	3.17	924	5160	4.43	1013	5650	5.83	1094	6100	7.34
50	32⅛"	2.16	744	5690	3.92	832	6360	5.47	912	6970	7.19	984	7530	9.06
55	35⅜"	2.61	676	6890	4.74	756	7700	6.62	829	8440	8.70	895	9110	11.0
60	38½"	3.13	620	8200	5.64	693	9160	7.88	760	10040	10.4	820	10840	13.1
70	45"	4.26	532	11540	7.67	594	12470	10.7	651	13660	14.1	703	14760	17.8
80	51⅜"	5.54	465	14570	10.0	520	16290	14.0	570	17850	18.4	615	19280	23.2
90	57⅞"	7.10	413	18440	12.7	462	20600	17.7	506	22590	23.3	547	24400	29.4
100	64"	8.75	372	22770	15.7	416	25460	21.9	456	27900	28.8	492	30120	36.3
110	70¾"	10.57	338	27540	19.0	378	30800	26.5	414	33740	34.8	448	36450	43.9
120	77¼"	13.00	310	32780	22.6	347	36660	31.5	380	40650	41.4	410	43380	52.2
130	83½"	14.85	286	38470	26.5	320	43020	37.0	351	47100	48.6	379	50900	61.3
140	90"	17.20	266	44630	30.7	297	49890	42.9	326	54750	56.4	352	59040	71.0
150	96½"	19.70	248	51220	35.3	277	57260	49.3	304	62740	64.8	328	67770	81.6
160	103"	22.40	233	58270	40.1	260	65170	56.0	285	71370	73.6	308	77110	92.8
170	109¼"	25.40	219	65790	45.3	245	73570	63.3	268	80590	83.1	290	87060	104.8
180	115"	28.50	207	73760	50.7	231	82480	70.9	253	90340	93.2	274	97600	117.5
190	122¼"	31.70	196	82180	56.5	219	91900	79.0	240	100670	103.4	259	108740	130.9
200	128½"	35.30	186	91060	62.7	208	101800	87.6	228	111540	115.1	246	120490	145.0
210	135"	38.7	177	100390	69.1	198	112270	96.5	217	122980	126.9	234	132830	159.9
220	141½"	42.2	169	110170	75.8	189	123200	105.9	207	134970	139.3	224	145780	175.5
230	148"	46.5	162	120420	82.9	181	134670	115.8	198	147510	152.2	214	159310	191.8

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	A. P. M. per R. P. M.	⅜" Static Press. or 0.217 Oz.			½" Static Press. or 0.288 Oz.			⅝" Static Press. or 0.360 Oz.			¾" Static Press. or 0.433 Oz.			⅞" Static Press. or 0.505 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.66	606	1000	0.16	700	1160	0.25	783	1300	0.35	857	1420	0.46	925	1535	0.58
35	2.61	520	1360	0.22	601	1570	0.34	672	1755	0.47	736	1925	0.62	795	2075	0.79
40	3.93	456	1790	0.29	526	2065	0.45	588	2310	0.62	644	2530	0.82	695	2730	1.03
45	5.57	404	2255	0.37	467	2600	0.56	522	2910	0.79	571	3185	1.03	617	3440	1.30
50	7.65	364	2785	0.45	421	3220	0.70	470	3600	0.97	515	3940	1.28	556	4260	1.61
55	10.18	331	3370	0.55	382	3890	0.84	427	4350	1.18	468	4765	1.55	505	5140	1.95
60	13.25	303	4010	0.65	350	4630	1.00	391	5180	1.40	429	5675	1.84	463	6125	2.32
70	21.00	260	5465	0.89	301	6320	1.36	336	7060	1.91	368	7730	2.51	398	8350	3.16
80	31.38	227	7120	1.16	262	8230	1.78	293	9200	2.49	321	10080	3.28	347	10880	4.13
90	44.60	202	9020	1.47	233	10410	2.25	261	11640	3.15	286	12750	4.15	309	13780	5.22
100	61.30	182	11140	1.81	210	12880	2.78	235	14400	3.89	257	15750	5.12	278	17020	6.44
110	81.50	165	13480	2.19	191	15550	3.37	214	17400	4.71	234	19100	6.19	253	20600	7.80
120	105.60	152	16030	2.62	175	18530	4.04	196	20700	5.63	215	22700	7.40	232	24500	9.35
130	134.00	140	18700	3.05	161	21600	4.70	180	24150	6.57	198	26450	8.64	213	28600	10.90
140	168.00	130	21830	3.54	150	25200	5.45	168	28200	7.60	184	30850	10.00	198	33350	12.60
150	206.50	121	25050	4.04	140	28950	6.21	157	32350	8.70	171	35400	11.40	185	38250	14.40
160	249.50	114	28400	4.61	132	32800	7.08	147	36700	9.93	161	40200	13.05	174	43400	16.45
170	300.00	107	32200	5.23	124	37150	8.04	138	41600	11.25	152	45500	14.75	164	49150	18.65
180	357.50	101	36150	5.86	117	41700	9.00	130	46700	12.60	143	51100	16.55	154	55200	20.85
190	420.00	96	40150	6.51	110	46300	10.00	123	51800	14.00	135	56700	18.40	146	61250	23.20
200	491.50	91	44600	7.22	105	51500	11.10	117	57600	15.55	128	63100	20.45	138	68200	25.75
210	568.50	86	49100	7.95	100	56650	12.20	111	63400	17.10	122	69400	22.50	132	75000	28.30
220	651.00	83	53800	8.75	96	62150	13.45	107	69500	18.85	117	76100	24.75	126	82200	31.15
230	745.00	79	58900	9.54	91	68000	14.70	102	75200	20.55	112	83300	27.00	121	89900	34.00

Total Pressure is 126% of the Rated Static Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	A. P. M. per R. P. M.	1" Static Press. or 0.577 Oz.			1¼" Static Press. or 0.721 Oz.			1½" Static Press. or 0.865 Oz.			1¾" Static Press. or 1.010 Oz.			2" Static Press. or 1.154 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.66	990	1640	0.71	1110	1830	0.99	1212	2010	1.31	1310	2170	1.64	1400	2320	2.01
35	2.61	850	2220	0.96	950	2480	1.34	1041	2720	1.76	1125	2940	2.22	1200	3140	2.71
40	3.93	744	2920	1.26	831	3260	1.76	912	3580	2.32	985	3860	2.91	1050	4135	3.56
45	5.57	660	3680	1.59	738	4110	2.22	809	4510	2.93	874	4870	3.68	934	5210	4.50
50	7.65	595	4550	1.97	665	5080	2.75	729	5580	3.63	787	6020	4.55	842	6440	5.57
55	10.18	540	5500	2.38	604	6150	3.33	662	6740	4.38	715	7280	5.51	765	7780	6.73
60	13.25	495	6550	2.83	554	7320	3.96	606	8030	5.21	655	8670	6.55	700	9260	8.00
70	21.00	425	8930	3.86	475	9990	5.40	521	10920	7.11	562	11810	8.93	601	12630	10.91
80	31.38	371	11630	5.04	415	13000	7.05	454	14250	9.29	491	15400	11.65	525	16450	14.26
90	44.60	330	14730	6.38	369	16480	8.93	404	18050	11.72	437	19500	14.74	467	20850	18.05
100	61.30	297	18200	7.87	332	20350	11.00	364	22300	14.45	393	24080	18.20	420	25750	22.25
110	81.50	270	22000	9.53	302	24600	13.35	331	26950	17.50	357	29100	22.05	382	31100	26.95
120	105.60	248	26200	11.40	277	29300	15.95	304	32080	21.00	328	34650	26.40	351	37050	32.21
130	134.00	228	30550	13.30	255	34150	18.60	279	37410	24.50	302	40400	30.75	323	43250	37.60
140	168.00	212	35650	15.40	237	39850	21.55	260	43700	28.40	281	47200	35.60	300	50400	43.60
150	206.50	198	40900	17.60	221	45750	24.60	242	50150	32.45	262	54150	40.70	280	57900	49.75
160	249.50	186	46450	20.10	208	51850	28.15	228	56900	37.05	246	61400	46.50	263	65700	56.80
170	300.00	175	52550	22.75	196	58800	31.80	214	64400	41.90	232	69500	52.60	248	74300	64.30
180	357.50	165	59000	25.50	184	66000	35.70	202	72250	46.15	218	78100	59.00	234	83500	72.15
190	420.00	156	65500	28.35	174	73250	39.65	191	80250	52.25	206	86700	65.55	221	92650	80.15
200	491.50	148	72850	31.45	165	81450	44.00	181	89200	57.95	196	96400	72.75	209	103000	89.00
210	568.50	141	80150	34.60	158	89550	48.50	173	98200	63.75	187	106000	80.00	199	113300	97.80
220	651.00	135	87900	38.10	151	98250	53.35	165	107800	70.20	178	116200	88.15	191	124300	107.80
230	745.00	129	96150	41.55	144	107500	58.25	158	117850	76.50	170	125800	96.10	183	136000	117.40

Total Pressure is 126% of the Rated Static Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

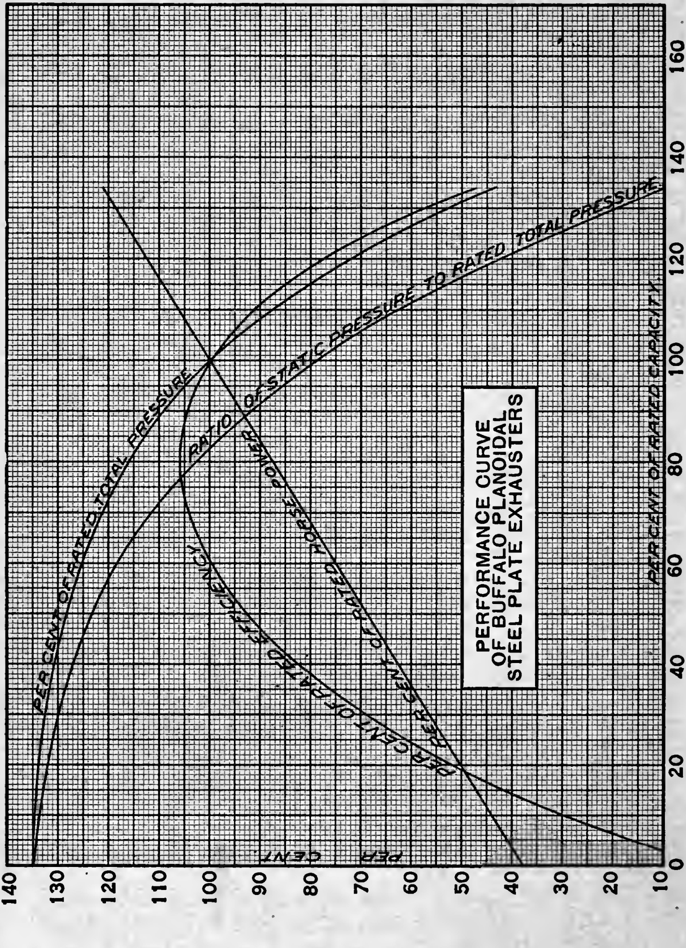
Size	A. P. M. per R. P. M.	2 ¼" Static Press. or 1.298 Oz.			2 ½" Static Press. or 1.442 Oz.			2 ¾" Static Press. or 1.586 Oz.			3" Static Press. or 1.734 Oz.			3 ½" Static Press. or 2.019 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.66	1485	2460	2.40	1565	2595	2.81	1640	2720	3.24	1715	2840	3.69	1852	3070	4.66
35	2.61	1275	3330	3.24	1343	3510	3.80	1410	3680	4.38	1472	3845	4.99	1590	4155	6.30
40	3.93	1117	4380	4.26	1177	4620	4.98	1233	4840	5.74	1288	5060	6.56	1392	5460	8.26
45	5.57	990	5500	5.37	1044	5825	6.29	1093	6100	7.25	1143	6375	8.28	1235	6890	10.43
50	7.65	893	6830	6.65	940	7200	7.78	986	7540	8.98	1030	7880	10.24	1112	8510	12.92
55	10.18	810	8250	8.04	854	8700	9.41	896	9120	10.84	936	9530	12.38	1010	10290	15.60
60	13.25	743	9830	9.55	783	10370	11.19	821	10870	12.90	858	11340	14.71	926	12250	18.55
70	21.00	638	13400	13.04	673	14120	15.27	705	14800	17.60	736	15460	20.08	795	16700	25.33
80	31.38	557	17470	17.00	587	18400	19.92	615	19300	22.88	643	20150	26.20	694	21750	33.08
90	44.60	495	22100	21.53	522	23300	25.25	547	24420	29.08	572	25500	33.20	617	27550	41.80
100	61.30	446	27300	26.57	470	28800	31.10	493	30200	35.85	515	31530	40.90	556	34050	51.60
110	81.50	405	33000	32.15	427	34800	37.70	448	36500	43.40	468	38100	49.60	505	41200	62.50
120	105.60	372	39300	38.50	392	41400	45.10	412	43400	51.95	429	45400	59.40	464	49000	74.70
130	134.00	342	45800	44.90	361	48350	52.60	378	50650	60.60	395	52900	69.25	427	57200	87.20
140	168.00	318	53500	52.00	335	56400	60.90	352	59150	70.20	367	61750	80.25	397	66700	101.00
150	206.50	297	61400	59.40	313	64750	69.60	328	67800	80.20	343	70900	91.70	371	76600	115.30
160	249.50	279	69700	67.90	294	73500	79.50	308	77000	91.60	322	80400	104.50	348	86900	131.80
170	300.00	263	78850	76.80	277	83200	90.00	290	87200	103.70	303	91000	118.20	328	98400	149.20
180	357.50	248	88500	86.10	261	93400	100.90	274	97800	116.30	286	102200	132.60	309	110400	167.10
190	420.00	234	98300	95.80	247	103700	112.00	259	108700	129.20	270	113300	147.30	292	122500	185.80
200	491.50	222	109300	106.20	234	115100	124.30	246	120800	143.30	257	126100	163.70	277	136300	206.30
210	568.50	212	120200	116.80	223	126800	136.80	234	133000	157.80	244	138800	179.90	264	150000	227.00
220	651.00	203	131800	128.60	214	139000	150.50	224	145800	173.50	234	152200	198.00	253	164500	249.90
230	745.00	194	144200	140.20	204	152100	164.30	214	159400	189.40	223	166500	216.00	241	179900	272.30

Total Pressure is 126% of the Rated Static Pressure

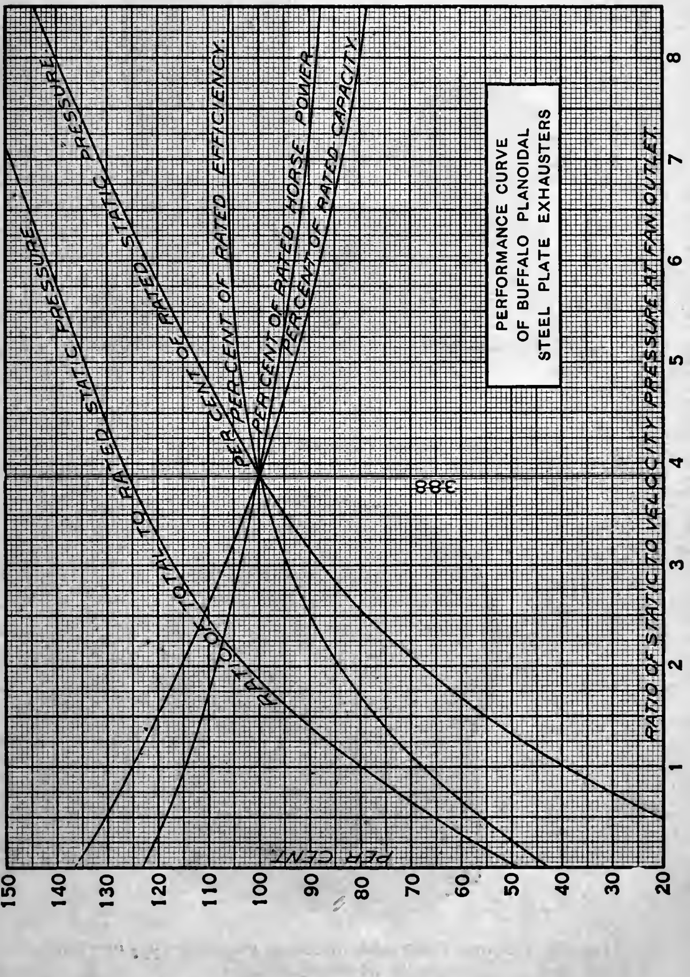
CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS (TYPE.L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	A. P. M. per R. P. M.	4″ Static Press. or 2.307 Oz.			4½ Static Press. or 2.595 Oz.			5″ Static Press. or 2.884 Oz.			5½″ Static Press. or 3.172 Oz.			6″ Static Press. or 3.460 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.66	1980	3280	5.68	2100	3480	6.78	2215	3670	7.94	2325	3845	9.16	2425	4030	10.43
35	2.61	1700	4440	7.68	1804	4710	9.16	1900	4965	10.73	1995	5210	12.38	2080	5440	14.10
40	3.93	1488	5840	10.08	1579	6195	12.03	1664	6530	14.10	1745	6850	16.25	1823	7150	18.52
45	5.57	1320	7360	12.72	1400	7805	15.18	1476	8230	17.80	1549	8635	20.50	1615	9020	23.40
50	7.65	1190	9100	15.76	1262	9650	18.80	1330	10180	22.05	1395	10680	25.40	1458	11140	29.00
55	10.18	1080	11000	19.04	1145	11680	22.73	1208	12300	26.60	1268	12900	30.70	1323	13480	35.00
60	13.25	990	13100	22.64	1050	13900	27.00	1108	14650	31.65	1160	15370	36.50	1212	16040	41.60
70	21.00	850	17860	30.88	901	18950	36.83	950	19980	43.15	997	20950	49.80	1040	21880	56.80
80	31.38	742	23280	40.30	787	24680	48.15	830	26000	56.40	870	27280	65.00	909	28530	74.10
90	44.60	660	29450	51.10	700	31250	60.90	738	32950	71.40	774	34550	82.30	809	36080	93.80
100	61.30	594	36400	62.96	630	38600	75.10	664	40700	88.00	697	42700	101.50	728	44600	115.60
110	81.50	540	44000	76.24	573	46650	91.00	604	49200	106.50	633	51600	123.00	661	53900	140.00
120	105.60	496	52400	91.20	526	55600	108.70	555	58600	127.50	582	61450	147.00	608	64200	167.70
130	134.00	456	61150	106.40	484	64800	127.00	510	68300	148.70	535	71700	171.80	559	74850	195.50
140	168.00	424	71350	123.20	450	75600	147.00	474	79750	172.10	498	83700	198.70	519	87300	226.40
150	206.50	396	81800	140.80	420	86900	168.00	443	91500	197.00	464	96000	227.00	485	100100	258.80
160	249.50	372	92900	160.80	395	98500	192.00	416	103900	224.80	436	108900	259.30	456	113700	295.30
170	300.00	350	105100	182.00	371	111400	217.30	391	117500	254.50	411	123200	293.50	428	128800	334.50
180	357.50	330	118000	204.00	350	125200	243.50	369	132000	285.30	387	138400	329.00	404	144500	375.00
190	420.00	312	131000	226.80	331	139000	270.50	349	146500	317.00	366	153800	365.90	382	160400	416.50
200	491.50	296	145700	251.60	314	154500	300.50	331	163000	352.00	347	170900	406.00	363	178400	462.50
210	568.50	282	160300	276.80	299	170000	330.00	315	179100	387.50	331	188000	446.50	346	196000	509.00
220	651.00	270	175800	304.80	286	186400	363.50	302	196600	426.00	317	206100	491.50	331	215300	560.00
230	745.00	258	192300	332.40	274	204000	397.50	289	215000	465.00	303	225500	536.00	316	235500	611.00

Total Pressure is 126% of the Rated Static Pressure



PERFORMANCE CURVE OF BUFFALO PLANOIDAL STEEL PLATE EXHAUSTERS


PERFORMANCE CURVE
OF BUFFALO PLANOIDAL
STEEL PLATE EXHAUSTERS
RATIO OF TOTAL TO RATED STATIC PRESSURE.
PER CENT OF RATED STATIC PRESSURE.
PERCENT OF RATED EFFICIENCY.
PERCENT OF RATED HORSE POWER.
PERCENT OF RATED CAPACITY.
RATIO OF STATIC TO VELOCITY PRESSURE AT FAN OUTLET.
PER CENT
3.88
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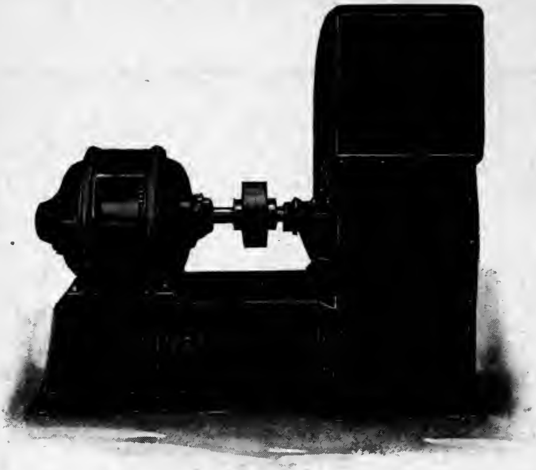


Motor Driven Planoidal Type "L" Fan

Left-Hand Bottom Horizontal Discharge Planoidal Type "L" Fan with Overhung Pulley

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS—TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	Diam. Blast-Wheel	Area of Outlet Sq. Ft.	½" Total Press. or 0.288 Oz.			⅝" Total Press. or 0.360 Oz.			¾" Total Press. or 0.433 Oz.			⅞" Total Press. or 0.505 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	19¼"	0.77	602	1025	0.16	672	1150	0.22	737	1260	0.30	795	1350	0.37
35	22½"	1.04	516	1400	0.22	576	1560	0.31	632	1710	0.40	681	1840	0.51
40	25¾"	1.36	451	1820	0.29	504	2040	0.40	553	2230	0.53	596	2410	0.66
45	29⅞"	1.75	401	2310	0.36	448	2580	0.51	491	2820	0.67	530	3050	0.84
50	32⅛"	2.16	361	2850	0.45	403	3180	0.62	442	3490	0.82	477	3760	1.03
55	35⅜"	2.61	328	3440	0.54	367	3850	0.76	402	4220	1.00	433	4550	1.25
60	38½"	3.13	301	4100	0.65	336	4580	0.90	368	5020	1.19	397	5410	1.49
70	45"	4.26	258	5580	0.88	288	6230	1.22	316	6830	1.61	341	7370	2.02
80	51⅜"	5.54	226	7290	1.15	252	8140	1.60	276	8920	2.11	298	9630	2.64
90	57⅞"	7.10	201	9220	1.45	224	10300	2.02	246	11290	2.67	265	12180	3.34
100	64¼"	8.75	181	11380	1.79	202	12720	2.50	221	13940	3.29	238	15040	4.12
110	70¾"	10.57	164	13780	2.17	183	15390	3.02	201	16870	3.98	217	18190	4.99
120	77¼"	13.00	150	16390	2.58	168	18320	3.59	184	20080	4.74	199	21650	5.94
130	83½"	14.85	139	19240	3.02	155	21500	4.22	170	23560	5.56	183	25410	6.97
140	90"	17.20	129	22310	3.51	144	24930	4.89	158	27330	6.45	170	29480	8.08
150	96½"	19.70	120	25610	4.03	134	28620	5.62	147	31370	7.40	159	33830	9.28
160	103"	22.40	113	29140	4.58	126	32560	6.38	138	35690	8.42	149	38500	10.6
170	109¼"	25.40	106	32900	5.17	119	36760	7.21	130	40290	9.50	140	43460	11.9
180	115¾"	28.50	100	36880	5.80	112	41200	8.08	123	45170	10.7	133	48720	13.4
190	122¼"	31.70	95	41100	6.46	106	45930	9.01	116	50330	11.9	126	54300	14.9
200	128½"	35.30	90	45540	7.16	101	50880	9.98	111	55760	13.2	119	60150	16.5
210	135"	38.7	86	50200	7.89	96	56100	11.0	105	61480	14.5	114	66310	18 2
220	141½"	42.2	82	55100	8.66	92	61550	12.1	101	67480	15.9	108	72780	20 0
230	148"	46.5	79	60210	9.47	88	67280	13.2	96	73750	17.4	104	79540	21 8

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS—TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	Diam. Blast-Wheel	Area Outlet Sq. Ft.	1″ Total Press. or 0.577 Oz.			1¼″ Total Press. or 0.721 Oz.			1½″ Total Press. or 0.865 Oz.			1¾″ Total Press. or 1.010 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	19¼″	0.77	851	1450	0.46	951	1620	0.64	1042	1770	0.84	1125	1920	1.05
35	22½″	1.04	729	1970	0.62	815	2200	0.87	893	2410	1.14	965	2610	1.44
40	25¾″	1.36	638	2580	0.81	713	2880	1.13	781	3150	1.49	844	3410	1.88
45	28⅞″	1.75	567	3260	1.03	634	3640	1.43	695	3990	1.88	750	4310	2.37
50	32⅛″	2.16	511	4030	1.27	571	4500	1.77	625	4930	2.32	675	5330	2.93
55	35⅜″	2.61	464	4870	1.53	519	5440	2.14	568	5960	2.81	614	6440	3.55
60	38½″	3.13	426	5800	1.82	476	6480	2.55	521	7100	3.35	563	7670	4.22
70	45″	4.26	365	7890	2.48	408	8820	3.46	447	9650	4.56	482	10450	5.74
80	51⅜″	5.54	319	10300	3.24	337	11520	4.53	391	12620	5.95	422	13630	7.50
90	57⅞″	7.10	284	13040	4.10	317	14580	5.73	347	15970	7.53	375	17250	9.49
100	64¼″	8.75	255	16100	5.06	285	18000	7.07	313	19720	9.30	338	21300	11.7
110	70¾″	10.57	232	19480	6.02	259	21780	8.55	284	23860	11.3	307	25770	14.2
120	77¼″	13.00	212	23180	7.29	238	25920	10.2	261	28390	13.4	281	30670	16.9
130	83½″	14.85	196	27210	8.55	220	30420	12.0	240	33320	15.7	260	36000	19.8
140	90″	17.20	182	31560	9.92	204	35280	13.9	223	38650	18.2	241	41750	23.0
150	96½″	19.70	170	36230	11.4	190	40500	15.9	208	44360	20.9	225	47930	26.4
160	103″	22.40	160	41220	13.0	178	46080	18.1	195	50470	23.8	211	54510	30.0
170	109¼″	25.40	150	46530	14.6	168	52020	20.4	184	56980	26.9	199	61560	33.9
180	115¾″	28.50	142	52160	16.4	159	58320	22.9	177	63880	30.1	188	69000	38.0
190	122¼″	31.70	134	58120	18.3	150	64980	25.5	165	71180	33.6	178	76900	42.3
200	128½″	35.30	128	64400	20.3	143	72000	28.3	156	78870	37.2	169	85200	46.9
210	135″	38.7	122	71000	22.3	136	79380	31.2	149	86950	41.0	161	93930	51.7
220	141½″	42.2	116	77920	24.5	130	87120	34.2	142	95430	45.0	154	103080	56.7
230	148″	46.5	111	85170	26.8	124	95220	37.4	136	104300	49.2	147	112680	62.0

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) UNDER AVERAGE WORKING CONDITIONS—TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	Diam. Blast-Wheel	Area Outlet Sq. Ft.	2" Total Press. or 1.154 Oz.			2½" Total Press. or 1.442 Oz.			3" Total Press. or 1.734 Oz.			3½" Total Press. or 2.019 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	19¼"	0.77	1203	2050	1.29	1345	2290	1.80	1473	2510	2.36	1590	2710	2.98
35	22½"	1.04	1031	2800	1.75	1153	3120	2.45	1263	3420	3.22	1363	3690	4.06
40	25¾"	1.36	902	3640	2.29	1009	4070	3.20	1105	4460	4.21	1192	4820	5.30
45	29⅞"	1.75	802	4610	2.90	897	5160	4.05	982	5650	5.32	1060	6100	6.71
50	32⅛"	2.16	722	5700	3.58	807	6360	5.00	884	6970	6.57	954	7530	8.28
55	35⅜"	2.61	656	6900	4.33	734	7700	6.05	804	8440	7.95	867	9110	10.0
60	38½"	3.13	602	8200	5.15	673	9160	7.20	737	10040	9.46	795	10840	11.9
70	45"	4.26	516	11150	7.01	577	12460	9.80	632	13660	12.9	682	14760	16.2
80	51⅜"	5.54	451	14570	9.16	504	16290	12.8	553	17850	16.8	596	19280	21.2
90	57⅞"	7.10	401	18390	11.6	448	20600	16.2	491	22520	21.3	530	24400	26.8
100	64¼"	8.75	361	22770	14.3	403	25460	20.0	442	27900	26.3	477	30120	33.1
110	70¾"	10.57	328	27540	17.3	367	30800	24.2	402	33740	31.8	434	36450	40.1
120	77¼"	13.00	301	32880	20.6	336	36660	28.8	369	40150	37.8	398	43380	47.7
130	83½"	14.85	278	38470	24.2	310	43020	33.8	340	47130	44.4	367	50900	56.1
140	90"	17.20	258	44630	28.1	288	49890	39.2	316	54660	51.5	341	59040	64.9
150	96½"	19.70	241	51220	32.2	269	57260	45.0	295	62740	59.1	318	67780	74.6
160	103"	22.40	226	58270	36.6	252	65170	51.2	276	71390	67.2	298	77110	84.8
170	109¼"	25.40	212	65790	41.4	237	73570	57.8	260	80590	75.9	281	87060	95.7
180	115¾"	28.50	201	73760	46.4	224	82480	64.8	246	90340	85.1	265	97600	107.3
190	122¼"	31.70	190	82180	51.7	212	91900	72.2	233	100670	94.8	251	108740	119.6
200	128½"	35.30	181	91060	57.3	202	101800	80.0	221	111540	105.1	239	120490	132.5
210	135"	38.7	172	100390	63.1	192	112270	88.2	211	122980	115.8	227	132830	146.1
220	141½"	42.2	164	110170	69.3	183	123200	96.8	201	134970	127.1	217	145780	160.3
230	148"	46.5	157	120420	75.8	176	134670	105.8	192	147530	138.9	208	159350	175.3

Static Pressure is 79% of the Rated Total Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	A. P. M. per R. P. M.	⅜" Static Press. or 0.217 Oz.			½" Static Press. or 0.288 Oz.			⅝" Static Press. or 0.360 Oz.			¾" Static Press. or 0.433 Oz.			⅞" Static Press. or 0.505 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.71	586	1000	0.15	678	1160	0.23	758	1300	0.32	830	1420	0.42	896	1535	0.53
35	2.71	502	1360	0.20	580	1570	0.31	648	1755	0.44	710	1925	0.58	767	2075	0.73
40	4.06	440	1790	0.27	508	2065	0.41	568	2310	0.57	623	2530	0.75	673	2730	0.95
45	5.76	391	2255	0.34	451	2600	0.52	505	2910	0.73	553	3185	0.96	597	3440	1.20
50	7.92	352	2785	0.42	407	3220	0.64	455	3600	0.90	498	3940	1.18	538	4260	1.48
55	10.50	320	3370	0.50	369	3890	0.77	413	4350	1.08	452	4765	1.42	488	5140	1.79
60	13.70	294	4010	0.60	339	4630	0.92	378	5180	1.29	415	5675	1.70	448	6125	2.13
70	21.75	251	5465	0.81	290	6320	1.25	324	7060	1.75	355	7730	2.31	384	8350	2.89
80	32.40	220	7120	1.07	254	8230	1.64	284	9200	2.29	315	10080	3.02	336	10880	3.79
90	46.20	195	9020	1.35	226	10410	2.08	252	11640	2.90	276	12750	3.82	298	13780	4.79
100	63.40	176	11140	1.66	203	12880	2.56	227	14400	3.58	248	15750	4.71	268	17020	5.91
110	84.30	160	13480	2.01	185	15550	3.10	207	17400	4.33	226	19100	5.71	244	20600	7.15
120	109.50	146	16030	2.39	169	18530	3.69	189	20700	5.15	207	22700	6.78	224	24500	8.51
130	138.20	135	18700	2.79	156	21600	4.31	175	24150	6.02	192	26450	7.93	207	28600	9.95
140	174.00	126	21830	3.25	145	25200	5.02	162	28200	7.00	177	30850	9.24	192	33350	11.58
150	214.00	117	25050	3.73	135	28950	5.76	151	32350	8.05	165	35400	10.60	179	38250	13.28
160	259.50	110	28400	4.26	127	32800	6.57	142	36700	9.17	154	40200	12.10	167	43400	15.15
170	311.00	104	32200	4.81	120	37150	7.42	134	41600	10.35	146	45500	13.65	158	49150	17.11
180	371.00	97	36150	5.38	112	41700	8.31	126	46700	11.60	138	51100	15.25	149	55200	19.15
190	434.00	93	40150	6.00	107	46300	9.26	119	51800	12.90	131	56700	17.05	141	61250	21.35
200	505.00	88	44600	6.65	102	51500	10.25	114	57600	14.30	125	63100	18.85	135	68200	23.65
210	585.00	84	49100	7.33	97	56650	11.30	108	63400	15.80	119	69400	20.80	128	75000	26.10
220	675.50	80	53800	8.05	92	62150	12.40	103	69500	17.30	113	76100	22.80	122	82200	28.60
230	769.00	77	58900	8.80	88	68000	13.60	98	75200	18.95	108	83300	24.95	117	89900	31.30

Total Pressure is 126% of the Rated Static Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

Size	A. P. M. per R. P. M.	1" Static Press. or 0.577 Oz.			1 1/4" Static Press. or 0.721 Oz.			1 1/2" Static Press. or 0.865 Oz.			1 3/4" Static Press. or 1.010 Oz.			2" Static Press. or 1.154 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.71	958	1640	0.65	1070	1830	0.91	1174	2010	1.19	1268	2170	1.51	1355	2320	1.84
35	2.71	820	2220	0.87	916	2480	1.24	1005	2720	1.63	1085	2940	2.06	1160	3140	2.52
40	4.06	719	2920	1.16	804	3260	1.62	880	3580	2.13	951	3860	2.69	1018	4135	3.28
45	5.76	639	3680	1.47	715	4110	2.05	783	4510	2.70	845	4870	3.40	904	5210	4.15
50	7.92	575	4550	1.82	643	5080	2.54	705	5580	3.35	760	6020	4.21	814	6440	5.15
55	10.50	522	5500	2.19	584	6150	3.06	640	6740	4.03	690	7280	5.07	738	7780	6.19
60	13.70	479	6550	2.61	536	7320	3.64	587	8030	4.80	634	8670	6.04	678	9260	7.38
70	21.75	410	8930	3.55	459	9990	4.96	502	10920	6.52	542	11810	8.23	580	12630	10.02
80	32.40	359	11630	4.65	401	13000	6.50	440	14250	8.55	475	15400	10.77	508	16450	13.12
90	46.20	319	14730	5.88	357	16480	8.22	391	18050	10.80	422	19500	13.60	451	20850	16.60
100	63.40	287	18200	7.25	321	20350	10.12	352	22300	13.32	380	24080	16.80	406	25750	20.48
110	84.30	261	22000	8.78	292	24600	12.28	320	26950	16.12	345	29100	20.35	369	31100	24.80
120	109.50	239	26200	10.44	267	29300	14.60	293	32080	19.18	316	34650	24.20	338	37050	29.50
130	138.20	221	30550	12.20	247	34150	17.04	271	37410	22.40	292	40400	28.25	313	43250	34.50
140	174.00	205	35650	14.20	229	39850	19.83	251	43700	26.10	271	47200	32.90	290	50400	40.15
150	214.00	191	40900	16.30	214	45750	22.75	234	50150	29.95	253	54150	37.75	270	57900	46.10
160	259.50	179	46450	18.60	200	51850	26.00	219	56900	34.15	237	61400	43.10	253	65700	52.60
170	311.00	169	52550	21.00	189	58800	29.35	207	64400	38.60	224	69500	48.60	239	74300	59.40
180	371.00	159	59000	23.50	178	66000	32.80	195	72250	43.15	210	78100	54.40	225	83500	66.40
190	434.00	151	65500	26.20	169	73250	36.60	185	80250	48.10	200	86700	60.70	214	92650	74.20
200	505.00	144	72850	29.00	161	81450	40.50	176	89200	53.30	191	96400	67.15	204	103000	82.00
210	585.00	137	80150	32.00	153	89550	44.70	168	98200	58.80	181	106000	74.10	194	113300	90.50
220	675.50	130	87900	35.10	145	98250	49.00	159	107800	64.50	172	116200	81.30	184	124300	99.40
230	769.00	125	96150	38.40	140	107500	53.65	153	117850	70.50	165	125800	88.90	177	136000	108.50

Total Pressure is 126% of the Rated Static Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

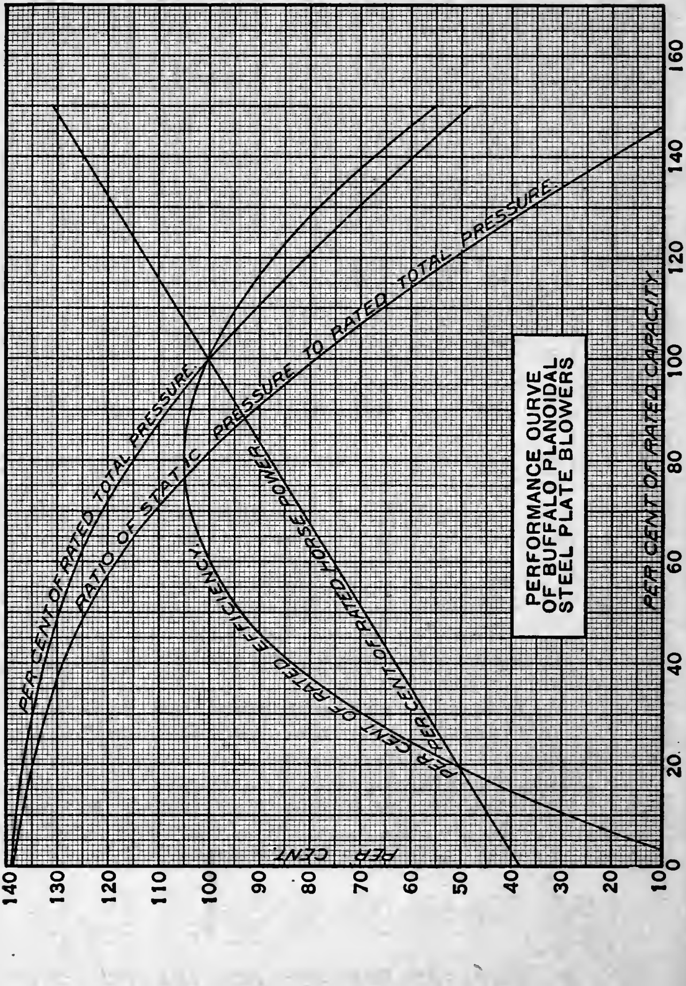
Size	A. P. M. per R. P. M.	2¼" Static Press. or 1.298 Oz.			2½" Static Press. or 1.442 Oz.			2¾" Static Press. or 1.586 Oz.			3" Static Press. or 1.734 Oz.			3½" Static Press. or 2.019 Oz.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	1.71	1438	2460	2.19	1515	2595	2.57	1589	2720	2.97	1660	2840	3.38	1792	3070	4.26
35	2.71	1230	3330	3.00	1295	3510	3.48	1360	3680	4.07	1420	3845	4.63	1534	4155	5.83
40	4.06	1078	4380	3.92	1135	4620	4.58	1190	4840	5.30	1245	5060	6.03	1345	5460	7.60
45	5.76	959	5502	4.96	1010	5825	5.81	1060	6100	6.72	1108	6375	7.63	1195	6890	9.63
50	7.92	863	6830	6.14	910	7200	7.20	954	7540	8.32	996	7880	9.45	1076	8510	11.91
55	10.50	783	8250	7.40	826	8700	8.66	865	9120	10.00	904	9530	11.38	976	10290	14.34
60	13.70	719	9830	8.80	758	10370	10.31	795	10870	11.95	830	11340	13.55	896	12250	17.10
70	21.75	615	13400	11.98	648	14120	14.03	680	14800	16.23	710	15460	18.45	767	16700	23.25
80	32.40	539	17470	15.70	568	18400	18.40	595	19300	21.30	621	20150	24.20	672	21750	30.50
90	46.20	479	22100	19.85	505	23300	23.30	529	24420	26.90	553	25500	30.55	597	27550	38.50
100	63.40	430	27300	24.50	454	28800	28.70	476	30200	33.20	497	31530	37.70	537	34050	47.50
110	84.30	392	33000	29.60	413	34800	34.70	433	36500	40.15	452	38100	45.60	488	41200	57.50
120	109.50	358	39300	35.25	378	41400	41.30	396	43400	47.80	414	45400	54.25	447	49000	68.40
130	138.20	332	45800	41.15	350	48350	48.25	366	50650	55.80	383	52900	63.40	413	57200	80.00
140	174.00	308	53500	47.90	324	56400	56.15	340	59150	65.00	355	61750	73.80	384	66700	93.00
150	214.00	287	61400	55.00	302	64750	64.50	317	67800	74.50	331	70900	84.70	358	76600	106.80
160	259.50	269	69700	62.80	283	73500	73.50	297	77000	85.00	310	80400	96.60	335	86900	121.80
170	311.00	254	78850	70.90	267	83200	83.00	280	87200	96.00	293	91000	109.00	316	98400	137.50
180	371.00	239	88500	79.30	251	93400	93.00	264	97800	107.50	277	102200	122.20	298	110400	154.00
190	434.00	227	98300	88.40	239	103700	103.60	250	108700	119.80	262	113300	136.00	282	122500	171.50
200	505.00	216	109300	97.80	228	115100	114.70	239	120800	132.70	250	126100	150.80	269	136300	190.00
210	585.00	206	120200	108.00	217	126800	126.50	227	133000	146.20	238	138800	166.30	257	150000	209.50
220	675.50	195	131800	118.50	206	139000	139.80	216	145800	160.50	225	152200	182.50	243	164500	230.00
230	679.00	188	144200	129.50	198	152100	151.90	207	159400	175.50	217	165500	199.50	234	179900	251.50

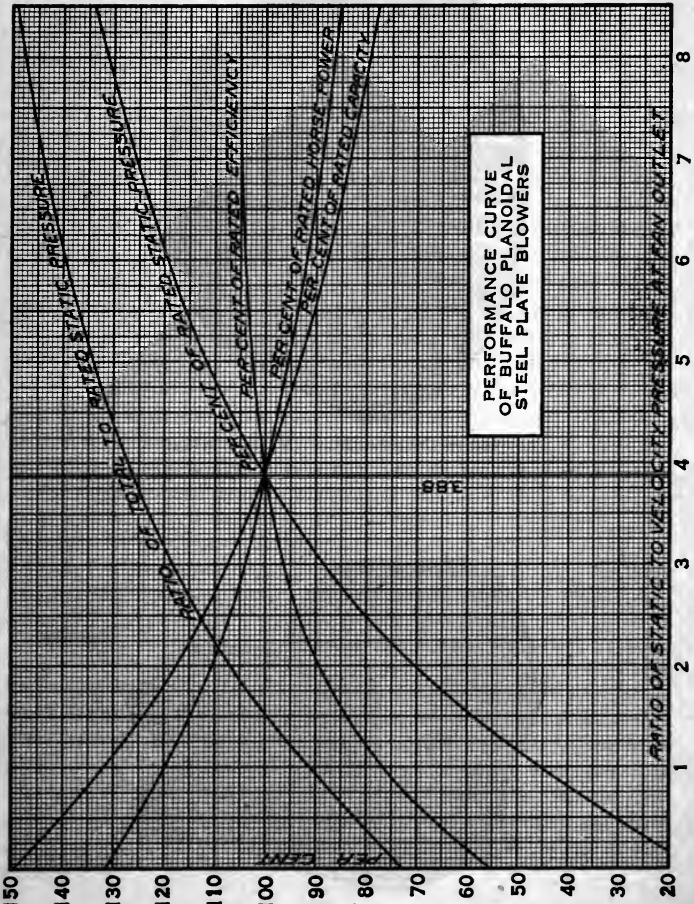
Total Pressure is 126% of the Rated Static Pressure

CAPACITIES OF BUFFALO PLANOIDAL STEEL PLATE BLOWERS (TYPE L) AT TEMPERATURE OF 70° F. AND 29.92 INCHES BAROMETER

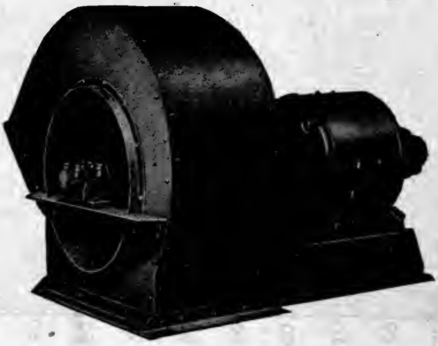
Size	A. P. M. per R. P. M.	4″ Static Press. or 2.307 Oz.			4½″ Static Press. or 2.595 Oz.			5″ Static Press. or 2.884 Oz.			5½″ Static Press. or 3.172 Oz.			6″ Static Press. or 3.460 Oz.		
		R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
30	1.71	1916	3280	5.20	2035	3480	6.20	2140	3670	7.27	2245	3845	8.36	2345	4030	9.55
35	2.71	1640	4440	7.12	1740	4710	8.50	1833	4965	9.95	1925	5210	11.45	2010	5440	13.08
40	4.06	1438	5840	9.28	1525	6195	10.08	1608	6530	12.98	1685	6850	14.91	1760	7150	17.05
45	5.76	1278	7360	11.76	1356	7805	14.01	1430	8230	16.44	1499	8635	18.90	1564	9020	21.60
50	7.92	1150	9100	14.57	1220	9650	17.37	1285	10180	20.35	1349	10680	23.40	1410	11140	26.75
55	10.50	1044	11000	17.52	1108	11680	20.90	1168	12300	24.50	1223	12900	28.15	1279	13480	32.20
60	13.70	958	13100	20.88	1018	13900	24.90	1070	14650	29.20	1122	15370	33.60	1173	16040	38.40
70	21.75	820	17860	28.40	870	18950	33.90	917	19980	39.70	962	20950	45.70	1003	21880	52.10
80	32.40	718	23280	37.20	762	24680	44.40	803	26000	52.00	842	27280	59.80	880	28530	68.30
90	46.20	638	29450	47.00	677	31250	56.10	714	32950	65.70	749	34550	75.60	782	36080	86.50
100	63.40	574	36400	58.00	609	38600	69.20	642	40700	81.10	673	42700	93.20	703	44600	106.50
110	84.30	522	44000	70.25	554	46650	83.80	583	49200	98.20	612	51600	112.90	640	53900	129.00
120	109.50	478	52400	83.52	507	55600	99.60	534	58600	116.80	561	61450	134.30	585	64200	153.30
130	138.20	442	61150	97.60	469	64800	116.30	494	68300	136.30	518	71700	157.00	542	74850	179.20
140	174.00	410	71350	113.80	435	75600	135.50	458	79750	158.90	481	83700	182.70	502	87300	209.00
150	214.00	382	81800	130.40	405	86900	155.50	427	91500	182.20	448	96000	209.50	468	100100	239.50
160	259.50	358	92900	148.80	380	98500	177.50	400	103900	208.00	420	108900	239.00	438	113700	273.00
170	311.00	338	105100	168.00	359	111400	200.50	378	117500	235.00	396	123200	270.00	414	128800	308.50
180	371.00	318	118000	188.00	338	125200	224.50	356	132000	263.00	373	138400	302.00	389	144500	345.50
190	434.00	302	131000	209.60	321	139000	250.00	338	146500	293.00	354	153800	337.00	370	160400	385.00
200	505.00	288	145700	232.00	306	154500	277.00	322	163000	324.50	338	170900	373.00	353	178400	426.00
210	585.00	274	160300	256.00	291	170000	305.00	306	179100	358.00	321	188000	412.00	336	196000	470.00
220	675.50	260	175800	280.80	276	186400	335.00	291	196600	393.00	305	206100	451.50	318	215300	516.00
230	769.00	250	192300	307.20	265	204000	367.00	279	215000	429.00	293	225500	494.00	306	235500	564.00

Total Pressure is 126% of the Rated Static Pressure


PERFORMANCE CURVE
OF BUFFALO PLANOIDAL
STEEL PLATE BLOWERS
PER CENT OF RATED TOTAL PRESSURE.
RATIO OF STATIC PRESSURE TO RATED TOTAL PRESSURE.
PER CENT OF RATED EFFICIENCY.
PER CENT OF RATED HORSE POWER.
PER CENT OF RATED CAPACITY.
PER CENT.
0
20
40
60
80
100
120
140
160
140
130
120
110
100
90
80
70
60
50
40
30
20
10


PERFORMANCE CURVE
OF BUFFALO PLANOIDAL
STEEL PLATE BLOWERS
RATIO OF TOTAL TO RATED STATIC PRESSURE
PER CENT OF RATED STATIC PRESSURE
PER CENT OF RATED EFFICIENCY
PER CENT OF RATED HORSE POWER
PER CENT OF RATED CAPACITY
RATIO OF STATIC TO VELOCITY PRESSURE AT FAN OUTLET
PER CENT
3.88
150
140
130
120
110
100
90
80
70
60
50
40
30
20
1
2
3
4
5
6
7
8

Niagara Conoidal Type "N" Fan Wheel



Motor Driven Niagara Conoidal Type "N" Fan

Niagara Conoidal Capacity Tables

The fan capacity tables on pages 228 to 273 refer to the single inlet Niagara Conoidal fans. It will be noted that there are two sets of these tables, the first based on total pressures of from ⅜ to 4 inches, and the second set for static pressures. The tables on pages 228 to 231 give the speeds, capacities, and horsepowers for the different sizes when operating approximately at the point of highest total efficiency. Under these conditions the static pressure will be 77.5 per cent. of the total pressure as given in the table. These are termed the rated capacity tables for these fans, and are similar in character to those given for the Planoidal and other fans. Double width fans with two inlets give double the capacities and horsepowers given in the tables.

The static pressure tables on pages 232 to 273 give the capacities, speeds and horsepowers of these fans at static pressures of 0.25 to 2.5 inches of water, and with velocities at the fan outlet of 1000 to 4000 feet per minute. Thus we have the performance not only at the point of maximum efficiency, but at both sides of this point on the performance curve. It will be noted that the peculiar performance of the Niagara Conoidal fan gives a wide range of capacities at constant static pressure with but little variation in speed and but very slight change in total efficiency. The tables on pages 274 and 275 show the total efficiency at various pressures and outlet velocities. While it is generally advisable to operate a fan at or near its most efficient point, it may frequently be necessary to make a slight sacrifice in efficiency in order to meet special conditions.

Particular attention should be used in public building work to keep the fan outlet velocity about 1800 feet per minute in order to insure quietness of operation, with a maximum allowable velocity of 2200 for such work. For industrial installations where higher duct velocities are the rule and absolute quietness of operation is not essential, outlet velocities as high as 4000 may be used. For practical examples in the use of these tables see page 186.

CAPACITIES OF BUFFALO NIAGARA CONOIDAL FANS (TYPE N) UNDER AVERAGE WORKING CONDITIONS AT 70° F. AND 29.92 INCHES BAROMETER

Fan No.	Mean Dia. of Blast-Wheel	Area of Outlet Sq. Ft.	3/8" Total Press. or 0.217 Oz.			1/2" Total Press. or 0.288 Oz.			5/8" Total Press. or 0.360 Oz.			3/4" Total Press. or 0.433 Oz.		
			R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
3	15 5/8"	1.31	413	1490	0.13	478	1720	0.19	533	1930	0.27	585	2110	0.35
3 1/2	18 1/8"	1.79	354	2030	0.17	409	2350	0.26	457	2620	0.37	501	2870	0.48
4	20 1/2"	2.33	310	2650	0.22	358	3070	0.34	400	3430	0.48	439	3750	0.63
4 1/2	23 1/2"	2.95	276	3360	0.28	318	3880	0.43	356	4340	0.60	390	4750	0.80
5	26 1/8"	3.64	248	4150	0.35	287	4790	0.53	320	5350	0.74	351	5870	0.98
5 1/2	28 3/4"	4.41	225	5020	0.42	260	5800	0.65	291	6470	0.90	319	7100	1.19
6	31 3/8"	5.25	207	5970	0.50	239	6900	0.77	267	7710	1.07	292	8450	1.41
7	36 1/2"	7.14	177	8130	0.68	205	9400	1.05	229	10490	1.46	251	11500	1.92
8	42"	9.33	155	10610	0.89	179	12260	1.37	200	13700	1.91	219	15020	2.51
9	47"	11.81	138	13450	1.12	159	15520	1.73	178	17340	2.41	195	19000	3.18
10	52"	14.58	124	16580	1.39	143	19160	2.14	160	21400	2.98	175	23460	3.93
11	58"	17.64	113	20070	1.68	130	23180	2.58	146	25900	3.60	160	28390	4.75
12	63"	21.00	104	23880	2.00	119	27590	3.08	133	30820	4.29	146	33780	5.65
13	68"	24.65	95	28040	2.35	110	32370	3.61	123	36180	5.03	135	39650	6.63
14	73"	28.68	89	32520	2.72	102	37550	4.19	114	41950	5.84	125	45990	7.69
15	78"	32.80	83	37330	3.13	96	43100	4.80	107	48160	6.70	117	52790	8.83
16	84"	37.32	78	42470	3.56	90	49040	5.47	100	54790	7.62	110	60060	10.1
17	89"	42.14	73	47950	4.01	84	55370	6.17	94	61860	8.60	103	67800	11.4
18	94"	47.24	69	53750	4.49	80	62060	6.92	89	69340	9.64	98	76010	12.7
19	99"	52.63	65	59890	5.00	75	69160	7.71	84	77260	10.8	92	84700	14.2
20	105"	58.32	62	66360	5.56	72	76640	8.54	80	85600	11.9	88	93850	15.7

Static Pressure is 77 1/2% of Total Pressure

CAPACITIES OF BUFFALO NIAGARA CONOIDAL FANS (TYPE N) UNDER AVERAGE WORKING CONDITIONS AT 70° F. AND 29.92 INCHES BAROMETER

Fan No.	Mean Dia. of Blast-Wheel	Area of Outlet Sq. Ft.	⅞" Total Press. or 0.505 Oz.			1" Total Press. or 0.577 Oz.			1¼" Total Press. or 0.721 Oz.			1½" Total Press. or 0.865 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
3	15⅝"	1.31	631	2280	.44	675	2440	.54	755	2730	.76	827	2990	1.00
3½	18⅛"	1.79	541	3100	.60	579	3320	.74	647	3710	1.04	709	4060	1.37
4	20½"	2.33	473	4050	.79	506	4340	.97	566	4850	1.35	620	5310	1.78
4½	23½"	2.95	420	5120	1.00	450	5490	1.22	503	6130	1.71	551	6720	2.25
5	26⅛"	3.64	378	6330	1.23	405	6770	1.51	453	7570	2.11	496	8300	2.77
5½	28¾"	4.41	344	7660	1.49	368	8200	1.83	412	9160	2.56	451	10040	3.36
6	31⅜"	5.25	315	9110	1.77	338	9750	2.17	378	10930	3.04	414	11940	4.00
7	36½"	7.14	270	12400	2.41	289	13280	2.96	324	14840	4.14	354	16260	5.44
8	42"	9.33	237	16200	3.15	253	17340	3.87	283	19390	5.41	310	21240	7.10
9	47"	11.81	210	20500	3.99	225	21950	4.89	252	24530	6.85	276	26880	8.99
10	52"	14.58	189	25310	4.92	203	27090	6.04	227	30290	8.45	248	33180	11.1
11	58"	17.64	172	30620	5.96	184	32780	7.31	206	36650	10.2	226	40150	13.4
12	63"	21.00	158	36440	7.09	169	39010	8.70	189	43620	12.2	207	47770	16.0
13	68"	24.65	146	42760	8.32	156	45780	10.2	174	51180	14.3	191	56070	18.8
14	73"	28.68	135	49600	9.65	145	53100	11.8	162	59370	16.6	177	65030	21.8
15	78"	32.80	126	56940	11.1	135	60960	13.6	151	68160	19.0	165	74650	25.0
16	84"	37.32	118	64780	12.6	127	69360	15.5	142	77540	21.6	155	84940	28.4
17	89"	42.14	111	73140	14.2	119	78300	17.5	133	87540	24.4	146	95900	32.1
18	94"	47.24	105	81990	16.0	113	87780	19.6	126	98140	27.4	138	107500	36.0
19	99"	52.63	100	91350	17.8	107	97800	21.8	119	109340	30.5	131	119780	40.1
20	105"	58.32	95	101220	19.7	101	108370	24.2	113	121160	33.8	124	132710	44.4

Static Pressure is 77½% of Total Pressure

CAPACITIES OF BUFFALO NIAGARA CONOIDAL FANS (TYPE N) UNDER AVERAGE WORKING CONDITIONS AT 70° F. AND 29.92 INCHES BAROMETER

Fan No.	Mean Dia. of Blast-Wheel	Area of Outlet Sq.Ft.	1 3/4" Total Press. or 1.010 Oz.			2" Total Press. or 1.154 Oz.			2 1/4" Total Press. or 1.298 Oz.			2 1/2" Total Press. or 1.442 Oz.		
			R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
3	15 5/8"	1.31	893	3230	1.26	955	3450	1.54	1013	3660	1.84	1067	3860	2.15
3 1/2	18 1/8"	1.79	766	4390	1.71	818	4690	2.09	868	4980	2.50	915	5250	2.93
4	20 1/2"	2.33	670	5740	2.24	716	6130	2.73	760	6500	3.26	801	6850	3.82
4 1/2	23 1/2"	2.95	596	7260	2.83	636	7760	3.46	675	8230	4.13	712	8670	4.83
5	26 1/8"	3.64	536	8960	3.49	573	9580	4.27	608	10160	5.09	640	10710	5.96
5 1/2	28 3/4"	4.41	487	10840	4.23	521	11590	5.17	552	12290	6.17	582	12960	7.22
6	31 3/8"	5.25	447	12900	5.03	477	13790	6.15	506	14630	7.34	534	15420	8.59
7	36 1/2"	7.14	383	17560	6.85	409	18770	8.37	434	19910	9.99	458	20990	11.7
8	42"	9.33	335	22940	8.95	358	24520	10.9	380	26010	13.1	400	27410	15.3
9	47"	11.81	298	29030	11.3	318	31020	13.8	338	32920	16.5	356	34700	19.3
10	52"	14.58	268	35840	14.0	286	38310	17.1	304	40640	20.4	320	42840	23.9
11	58"	17.64	244	43370	16.9	260	46360	20.7	276	49180	24.7	291	51800	28.9
12	63"	21.00	223	51610	20.1	239	55170	24.6	253	58510	29.4	267	61680	34.4
13	68"	24.65	206	60560	23.6	220	64730	28.9	234	68670	34.4	246	72380	40.3
14	73"	28.68	191	70250	27.4	205	75090	33.5	217	79650	40.0	229	83950	46.8
15	78"	32.80	179	80640	31.5	191	86200	38.4	203	91420	45.9	214	96380	53.7
16	84"	37.32	168	91760	35.8	179	98060	43.7	190	104030	52.2	200	109660	61.1
17	89"	42.14	158	103590	40.4	169	110720	49.4	179	117450	58.9	188	123800	69.0
18	94"	47.24	149	116120	45.3	159	124410	55.3	169	131660	66.0	178	138770	77.3
19	99"	52.63	141	129380	50.5	151	138280	61.7	160	146690	73.6	169	154620	86.2
20	105"	58.32	134	143360	55.9	143	153250	68.3	152	162550	81.5	160	171320	95.5

Static Pressure is 77 1/2% of Total Pressure

CAPACITIES OF BUFFALO NIAGARA CONOIDAL FANS (TYPE N) UNDER AVERAGE WORKING CONDITIONS AT 70° F. AND 29.92 INCHES BAROMETER

Fan No.	Mean Dia. of Blast-Wheel	Area of Outlet Sq. Ft.	2¾" Total Pressure or 1.586 Oz.			3" Total Press. or 1.734 Oz.			3½" Total Press. or 2.019 Oz.			4" Total Press. or 2.307 Oz.		
			R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.	R. P. M.	Vol.	H. P.
3	15⅝"	1.31	1120	4040	2.48	1169	4220	2.83	1263	4560	3.56	1350	4880	4.35
3½	18⅛"	1.79	960	5500	3.38	1002	5750	3.85	1083	6210	4.85	1157	6640	5.92
4	20½"	2.33	840	7190	4.41	877	7510	5.02	947	8110	6.32	1013	8670	7.73
4½	23½"	2.95	746	9100	5.58	780	9500	6.36	842	10260	8.01	900	10970	9.78
5	26⅛"	3.64	672	11230	6.88	702	11730	7.84	758	12670	9.87	810	13550	12.1
5½	28¾"	4.41	610	13590	8.33	638	14190	9.49	689	15330	12.0	736	16390	14.6
6	31⅜"	5.25	560	16170	9.91	585	16890	11.3	632	18250	14.2	675	19510	17.4
7	36½"	7.14	480	22020	13.5	501	23000	15.4	541	24840	19.4	579	26550	23.7
8	42"	9.33	420	28760	17.6	439	30040	20.1	474	32440	25.3	506	34680	30.9
9	47"	11.81	373	36390	22.3	390	38010	25.4	421	41050	32.0	450	43890	39.1
10	52"	14.58	336	44930	27.5	351	46930	31.4	379	50700	39.5	405	54180	48.3
11	58"	17.64	305	54360	33.3	319	56780	38.0	344	61330	47.8	368	65560	58.5
12	63"	21.00	280	64700	39.7	292	67570	45.2	316	72990	57.0	338	78020	69.6
13	68"	24.65	258	75920	46.5	270	79300	53.0	292	85650	66.8	312	91560	81.6
14	73"	28.68	240	88060	54.0	251	91970	61.5	271	99340	77.5	289	106200	94.7
15	78"	32.80	224	101080	62.0	234	105580	70.6	253	114050	89.0	270	121920	108.7
16	84"	37.32	210	115000	70.5	219	120130	80.3	237	129750	101.2	253	138700	123.7
17	89"	42.14	198	129840	79.6	206	135620	90.7	223	146490	114.3	238	156600	139.6
18	94"	47.24	187	145550	89.2	195	152020	101.7	211	164110	128.1	225	175550	156.5
19	99"	52.63	177	162170	99.4	185	169400	113.3	200	182970	142.7	213	195600	174.4
20	105"	58.32	168	179700	110.2	175	187680	125.5	190	202720	158.1	202	216720	193.2

Static Pressure is 77½% of Total Pressure

NO. 3 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	1310	0.063	387	.09	483	.15								
1100	1440	0.076	384	.11	477	.16								
1200	1570	0.090	387	.12	477	.17	557	.23						
1300	1710	0.106	393	.14	470	.18	550	.25	623	.32				
1400	1840	0.122	400	.16	473	.20	547	.26	617	.33	687	.42		
1500	1970	0.141	410	.18	477	.23	543	.28	613	.35	680	.43	743	.52
1600	2100	0.160	420	.21	480	.25	547	.31	610	.37	673	.45	733	.54
1700	2230	0.180	430	.24	490	.28	550	.34	607	.40	670	.48	727	.56
1800	2360	0.202	443	.28	500	.32	553	.37	610	.43	667	.51	723	.59
1900	2490	0.225	457	.31	510	.35	560	.41	613	.47	667	.54	720	.62
2000	2630	0.250	470	.35	520	.40	570	.45	617	.52	667	.58	720	.66
2100	2760	0.275	483	.39	530	.45	580	.50	623	.56	670	.63	720	.71
2200	2890	0.302	497	.44	543	.50	590	.55	633	.61	677	.68	723	.76
2300	3020	0.330	513	.49	557	.55	600	.61	643	.67	683	.73	727	.81
2400	3150	0.360	527	.55	570	.61	610	.67	650	.73	690	.80	733	.87
2500	3280	0.390	543	.60	583	.67	623	.74	660	.80	700	.86	740	.94
2600	3410	0.422	560	.67	597	.74	633	.81	673	.88	710	.94	747	1.02
2800	3670	0.489	590	.81	623	.89	660	.96	693	1.04	730	1.10	767	1.17
3000	3940	0.560	623	.99	657	1.04	687	1.14	720	1.22	753	1.29	780	1.36
3200	4190	0.638					717	1.33	747	1.42	780	1.50	810	1.58
3400	4460	0.721									807	1.75	833	1.84

NO. 3 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S. P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1300	1710	0.106	820	.58										
1400	1840	0.122	810	.59	920	.80	1027	1.00						
1500	1970	0.141	800	.62	913	.81	1017	1.04	1110	1.25				
1600	2100	0.160	793	.64	903	.84	1007	1.06	1100	1.29	1190	1.53		
1700	2230	0.180	783	.66	893	.86	997	1.09	1087	1.32	1177	1.58	1343	2.13
1800	2360	0.202	777	.68	883	.89	983	1.12	1077	1.35	1167	1.61	1330	2.16
1900	2490	0.225	773	.71	877	.92	977	1.14	1067	1.39	1157	1.65	1317	2.20
2000	2630	0.250	770	.75	873	.95	970	1.17	1057	1.42	1143	1.68	1303	2.24
2100	2760	0.275	770	.79	867	.99	960	1.22	1050	1.46	1133	1.73	1297	2.29
2200	2890	0.302	767	.84	863	1.03	953	1.25	1040	1.50	1127	1.76	1287	2.33
2300	3020	0.330	770	.89	860	1.08	950	1.30	1033	1.54	1120	1.81	1270	2.38
2400	3150	0.360	773	.95	860	1.13	947	1.35	1027	1.59	1107	1.85	1263	2.43
2500	3280	0.390	777	1.03	860	1.20	943	1.41	1023	1.64	1103	1.91	1253	2.49
2600	3410	0.422	783	1.09	863	1.26	940	1.47	1020	1.70	1097	1.96	1247	2.54
2800	3670	0.489	800	1.25	870	1.43	943	1.63	1013	1.84	1090	2.10	1233	2.67
3000	3940	0.560	820	1.44	883	1.61	950	1.81	1020	2.02	1087	2.25	1227	2.82
3200	4190	0.638	837	1.65	900	1.83	960	2.02	1023	2.23	1090	2.47	1217	3.00
3400	4460	0.721	863	1.90	920	2.06	980	2.26	1033	2.47	1093	2.69	1213	3.21
3600	4730	0.810	883	2.18	943	2.34	997	2.53	1050	2.76	1107	2.96	1220	3.48
3800	4990	0.900					1017	2.84	1067	3.04	1117	3.28	1227	3.76
4000	5250	1.000							1087	3.39	1133	3.60	1233	4.10

NO. 3½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	1790	0.063	332	.13	414	.20								
1100	1970	0.076	329	.14	409	.21								
1200	2140	0.090	332	.16	409	.23	477	.32						
1300	2320	0.106	337	.18	403	.25	472	.33	534	.43				
1400	2500	0.122	343	.21	406	.28	469	.36	529	.45	589	.57		
1500	2680	0.141	352	.24	409	.31	466	.38	526	.48	583	.59	637	.71
1600	2860	0.160	360	.28	412	.34	469	.42	523	.51	577	.62	629	.73
1700	3040	0.180	369	.32	422	.49	472	.46	520	.55	574	.65	623	.77
1800	3210	0.202	380	.37	429	.33	474	.51	523	.59	572	.69	620	.80
1900	3390	0.225	392	.42	437	.48	480	.56	526	.64	572	.74	617	.85
2000	3570	0.250	403	.48	446	.54	489	.62	529	.70	572	.79	617	.90
2100	3750	0.275	414	.53	454	.61	497	.68	534	.76	574	.86	617	.96
2200	3930	0.302	426	.59	466	.68	506	.75	543	.83	580	.92	620	1.03
2300	4110	0.330	440	.67	477	.75	514	.83	552	.91	586	1.00	623	1.10
2400	4290	0.360	452	.74	489	.83	523	.91	557	.99	592	1.09	629	1.18
2500	4470	0.390	466	.82	500	.91	534	1.01	566	1.08	600	1.17	634	1.27
2600	4640	0.422	480	.91	512	1.01	543	1.10	577	1.19	609	1.27	640	1.39
2800	5000	0.489	506	1.10	534	1.21	566	1.31	594	1.41	626	1.50	657	1.59
3000	5360	0.560	534	1.35	563	1.42	589	1.56	617	1.65	646	1.75	669	1.85
3200	5720	0.638					614	1.81	640	1.94	669	2.05	694	2.16
3400	6070	0.721									692	2.38	714	2.50

NO. 3½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	2320	0.106	703	.78										
1400	2500	0.122	694	.81	789	1.08	880	1.36						
1500	2680	0.141	686	.84	783	1.10	872	1.41	952	1.70				
1600	2860	0.160	680	.86	774	1.15	863	1.45	943	1.75	1020	2.08		
1700	3040	0.180	672	.89	766	1.17	854	1.48	932	1.79	1009	2.14	1151	2.89
1800	3210	0.202	666	.93	757	1.21	843	1.52	923	1.84	1000	2.19	1140	2.94
1900	3390	0.225	663	.97	752	1.25	837	1.56	914	1.89	992	2.24	1129	2.99
2000	3570	0.250	660	1.02	749	1.30	831	1.59	906	1.94	980	2.29	1117	3.05
2100	3750	0.275	660	1.08	743	1.35	823	1.65	900	1.99	972	2.35	1111	3.11
2200	3930	0.302	657	1.14	740	1.40	817	1.70	892	2.03	966	2.40	1103	3.17
2300	4110	0.330	660	1.22	737	1.47	814	1.77	886	2.10	960	2.46	1089	3.23
2400	4290	0.360	663	1.30	737	1.53	812	1.84	880	2.17	949	2.52	1083	3.31
2500	4470	0.390	666	1.40	737	1.63	809	1.91	877	2.23	946	2.60	1074	3.38
2600	4640	0.422	672	1.48	740	1.72	806	2.00	874	2.32	940	2.67	1069	3.46
2800	5000	0.489	686	1.70	746	1.95	809	2.22	869	2.50	934	2.86	1057	3.63
3000	5360	0.560	703	1.96	757	2.19	814	2.46	874	2.74	932	3.06	1052	3.84
3200	5720	0.638	717	2.24	772	2.49	823	2.75	877	3.04	934	3.36	1043	4.08
3400	6070	0.721	740	2.59	789	2.81	840	3.08	886	3.36	937	3.66	1040	4.36
3600	6430	0.810	757	2.97	809	3.19	854	3.44	900	3.75	949	4.03	1046	4.73
3800	6790	0.900					872	3.86	914	4.14	957	4.46	1052	5.12
4000	7140	1.000							932	4.61	972	4.90	1057	5.59

NO. 4 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	2330	0.063	290	.17	363	.26								
1100	2570	0.076	288	.19	358	.28								
1200	2800	0.090	290	.21	358	.30	418	.41						
1300	3030	0.106	295	.24	353	.33	413	.44	468	.56				
1400	3270	0.122	300	.28	355	.36	410	.47	463	.59	515	.74		
1500	3500	0.141	308	.32	358	.40	408	.50	460	.62	510	.77	558	.92
1600	3730	0.160	315	.37	360	.45	410	.55	458	.66	505	.80	550	.96
1700	3970	0.180	323	.42	368	.50	413	.60	455	.71	503	.85	545	1.00
1800	4220	0.202	333	.49	375	.56	415	.66	458	.77	500	.90	543	1.05
1900	4430	0.225	343	.55	383	.63	420	.73	460	.84	500	.96	540	1.11
2000	4670	0.250	353	.62	390	.71	428	.81	463	.92	500	1.04	540	1.17
2100	4900	0.275	363	.70	398	.80	435	.89	468	1.00	503	1.12	540	1.26
2200	5130	0.302	373	.78	408	.88	443	.98	475	1.08	508	1.21	543	1.35
2300	5370	0.330	385	.87	418	.98	450	1.08	483	1.19	513	1.31	545	1.44
2400	5600	0.360	395	.97	428	1.09	458	1.19	488	1.30	518	1.42	550	1.55
2500	5830	0.390	408	1.07	438	1.19	468	1.32	495	1.41	525	1.53	555	1.67
2600	6070	0.422	420	1.19	448	1.32	475	1.43	505	1.56	533	1.67	560	1.81
2800	6530	0.489	443	1.44	468	1.58	495	1.71	520	1.84	548	1.95	575	2.08
3000	7000	0.560	468	1.76	493	1.86	515	2.03	540	2.16	565	2.29	585	2.42
3200	7460	0.638					538	2.37	560	2.53	585	2.67	608	2.82
3400	7930	0.721									605	3.11	625	3.27

NO. 4 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S . P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	3030	0.106	615	1.03										
1400	3270	0.122	608	1.06	690	1.41	770	1.78						
1500	3500	0.141	600	1.09	685	1.44	763	1.84	833	2.23				
1600	3730	0.160	595	1.13	678	1.50	755	1.89	825	2.29	893	2.72		
1700	3970	0.180	588	1.17	670	1.53	748	1.94	815	2.34	883	2.80	1008	3.78
1800	4220	0.202	583	1.22	663	1.58	738	1.94	808	2.40	875	2.87	998	3.84
1900	4430	0.225	580	1.27	658	1.63	733	2.03	800	2.47	868	2.93	988	3.91
2000	4670	0.250	578	1.33	655	1.70	728	2.08	793	2.53	858	2.99	978	3.99
2100	4900	0.275	578	1.40	650	1.76	720	2.16	788	2.59	850	3.07	973	4.07
2200	5130	0.302	575	1.49	648	1.83	715	2.23	780	2.66	845	3.14	965	4.15
2300	5370	0.330	578	1.59	645	1.92	713	2.31	775	2.74	840	3.22	953	4.23
2400	5600	0.360	580	1.70	645	2.00	710	2.40	770	2.83	830	3.30	948	4.32
2500	5830	0.390	583	1.83	645	2.13	708	2.50	768	2.91	828	3.39	940	4.42
2600	6070	0.422	588	1.94	648	2.24	705	2.61	765	3.03	823	3.49	935	4.51
2800	6530	0.489	600	2.23	653	2.55	708	2.90	760	3.27	818	3.73	925	4.74
3000	7000	0.560	615	2.56	663	2.87	713	3.22	765	3.59	815	4.00	920	5.01
3200	7460	0.638	628	2.93	675	3.25	720	3.59	768	3.97	818	4.39	913	5.33
3400	7930	0.721	648	3.38	690	3.67	735	4.02	775	4.39	820	4.79	910	5.70
3600	8400	0.810	663	3.87	708	4.16	748	4.50	788	4.90	830	5.27	915	6.18
3800	8860	0.900					763	5.04	800	5.41	838	5.83	920	6.69
4000	9330	1.000							815	6.02	850	6.40	925	7.30

NO. 4½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	2950	0.063	258	0.21	322	0.33								
1100	3250	0.076	256	0.23	318	0.35								
1200	3540	0.090	258	0.27	318	0.38	371	0.52						
1300	3840	0.106	262	0.30	313	0.41	367	0.55	416	0.71				
1400	4130	0.122	267	0.35	316	0.46	365	0.59	411	0.75	458	0.93		
1500	4430	0.141	273	0.40	318	0.51	362	0.63	409	0.79	453	0.97	496	1.17
1600	4720	0.160	280	0.46	320	0.57	365	0.69	407	0.84	449	1.02	489	1.21
1700	5020	0.180	287	0.53	327	0.64	367	0.76	405	0.90	447	1.07	485	1.27
1800	5310	0.202	296	0.61	333	0.71	369	0.84	407	0.97	445	1.14	482	1.33
1900	5610	0.225	305	0.69	340	0.80	373	0.92	409	1.06	445	1.22	480	1.40
2000	5900	0.250	313	0.79	347	0.89	380	1.02	411	1.16	445	1.31	480	1.48
2100	6200	0.275	322	0.88	353	1.01	387	1.13	416	1.26	447	1.42	480	1.59
2200	6500	0.302	331	0.98	362	1.12	393	1.24	422	1.37	451	1.53	482	1.71
2300	6790	0.330	342	1.10	371	1.24	400	1.37	429	1.50	456	1.65	485	1.82
2400	7090	0.360	351	1.23	380	1.38	407	1.51	433	1.64	460	1.80	489	1.96
2500	7380	0.390	362	1.35	389	1.50	416	1.67	440	1.79	467	1.94	493	2.11
2600	7680	0.422	373	1.51	398	1.67	422	1.81	449	1.97	473	2.11	498	2.29
2800	8270	0.489	393	1.82	416	2.00	440	2.17	462	2.33	487	2.47	511	2.63
3000	8860	0.560	416	2.23	438	2.35	458	2.57	480	2.73	502	2.90	520	3.06
3200	9450	0.638					478	3.00	498	3.20	520	3.38	540	3.57
3400	10040	0.721									538	3.93	556	4.13

NO. 4½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	3840	0.106	547	1.30										
1400	4130	0.122	540	1.34	613	1.79	685	2.25						
1500	4430	0.141	533	1.38	609	1.82	678	2.33	740	2.82				
1600	4720	0.160	529	1.43	602	1.89	671	2.39	733	2.90	793	3.44		
1700	5020	0.180	522	1.48	596	1.93	665	2.45	725	2.96	785	3.54	896	4.78
1800	5310	0.202	518	1.54	589	2.00	656	2.51	718	3.04	778	3.63	887	4.86
1900	5610	0.225	516	1.60	585	2.07	651	2.57	711	3.12	771	3.71	878	4.94
2000	5900	0.250	513	1.69	582	2.15	647	2.63	704	3.20	762	3.79	869	5.04
2100	6200	0.275	513	1.78	578	2.23	640	2.74	700	3.28	756	3.89	865	5.14
2200	6500	0.302	511	1.89	576	2.31	636	2.82	696	3.36	751	3.97	858	5.25
2300	6790	0.330	513	2.01	573	2.43	633	2.92	689	3.46	747	4.07	847	5.35
2400	7090	0.360	516	2.15	573	2.53	631	3.04	685	3.59	738	4.17	842	5.47
2500	7380	0.390	518	2.31	573	2.69	629	3.16	682	3.69	736	4.29	836	5.59
2600	7680	0.422	522	2.45	576	2.84	627	3.30	680	3.83	731	4.42	831	5.71
2800	8270	0.489	533	2.82	580	3.22	629	3.67	676	4.13	727	4.72	822	5.99
3000	8860	0.560	547	3.24	589	3.63	633	4.07	680	4.54	725	5.06	818	6.34
3200	9450	0.638	558	3.71	600	4.11	640	4.54	682	5.02	727	5.55	811	6.74
3400	10040	0.721	576	4.27	613	4.64	653	5.08	689	5.55	729	6.06	809	7.21
3600	10630	0.810	589	4.90	629	5.27	665	5.69	700	6.20	738	6.66	813	7.82
3800	11220	0.900					678	6.38	711	6.85	745	7.37	818	8.46
4000	11810	1.000							725	7.61	756	8.10	822	9.23

NO. 5 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	3640	0.063	232	.26	290	.41								
1100	4010	0.076	230	.29	286	.44								
1200	4370	0.090	232	.33	286	.47	334	.65						
1300	4740	0.106	236	.38	282	.51	330	.68	374	.88				
1400	5100	0.122	240	.43	284	.56	328	.73	370	.92	412	1.15		
1500	5470	0.141	246	.50	286	.63	326	.78	368	.98	408	1.20	446	1.44
1600	5830	0.160	252	.57	288	.70	328	.86	366	1.04	404	1.26	440	1.49
1700	6190	0.180	258	.66	294	.79	330	.94	364	1.11	402	1.33	436	1.57
1800	6560	0.202	266	.76	300	.88	332	1.03	366	1.20	400	1.40	434	1.64
1900	6930	0.225	274	.86	306	.99	336	1.14	368	1.31	400	1.50	432	1.73
2000	7290	0.250	282	.97	312	1.11	342	1.26	370	1.43	400	1.62	432	1.83
2100	7660	0.275	290	1.09	318	1.24	348	1.39	374	1.56	402	1.75	432	1.96
2200	8010	0.302	298	1.21	326	1.38	354	1.53	380	1.69	406	1.89	434	2.11
2300	8380	0.330	308	1.36	334	1.55	360	1.69	386	1.85	410	2.04	436	2.25
2400	8750	0.360	316	1.51	342	1.70	366	1.86	390	2.03	414	2.22	440	2.41
2500	9100	0.390	326	1.67	350	1.86	374	2.06	396	2.21	420	2.40	444	2.60
2600	9480	0.422	336	1.86	358	2.06	380	2.24	404	2.43	426	2.60	448	2.83
2800	10200	0.489	354	2.25	374	2.46	396	2.68	416	2.88	438	3.05	460	3.25
3000	10940	0.560	374	2.75	394	2.90	412	3.18	432	3.38	452	3.58	468	3.78
3200	11660	0.638					430	3.70	448	3.95	468	4.18	486	4.40
3400	12390	0.721									484	4.85	500	5.10

NO. 5 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S. P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H.P.
1300	4740	0.106	492	1.60										
1400	5100	0.122	486	1.65	552	2.21	616	2.78						
1500	5470	0.141	480	1.71	548	2.25	610	2.88	666	3.48				
1600	5830	0.160	476	1.76	542	2.34	604	2.95	660	3.58	714	4.25		
1700	6190	0.180	470	1.82	536	2.39	598	3.03	652	3.65	706	4.38	806	5.90
1800	6560	0.202	466	1.90	530	2.47	590	3.10	646	3.75	700	4.48	798	6.00
1900	6930	0.225	464	1.98	526	2.55	586	3.18	640	3.85	694	4.58	790	6.10
2000	7290	0.250	462	2.08	524	2.65	582	3.25	634	3.95	686	4.68	782	6.23
2100	7660	0.275	462	2.19	520	2.75	576	3.38	630	4.05	680	4.80	778	6.35
2200	8010	0.302	460	2.33	518	2.85	572	3.48	624	4.15	676	4.90	772	6.48
2300	8380	0.330	462	2.48	516	3.00	570	3.60	620	4.28	672	5.03	762	6.60
2400	8750	0.360	464	2.65	516	3.13	568	3.75	616	4.44	664	5.15	758	6.75
2500	9100	0.390	466	2.85	516	3.33	566	3.90	614	4.55	662	5.30	752	6.90
2600	9480	0.422	470	3.03	518	3.50	564	4.08	612	4.73	658	5.45	748	7.05
2800	10200	0.489	480	3.48	522	3.98	566	4.53	608	5.10	654	5.83	740	7.40
3000	10940	0.560	492	4.00	530	4.48	570	5.03	612	5.60	652	6.25	736	7.83
3200	11660	0.638	502	4.57	540	5.08	576	5.60	614	6.20	654	6.85	730	8.32
3400	12390	0.721	518	5.27	552	5.73	588	6.28	620	6.85	656	7.48	728	8.90
3600	13120	0.810	530	6.05	566	6.50	598	7.03	630	7.65	664	8.22	732	9.65
3800	13850	0.900					610	7.88	640	8.46	670	9.10	736	10.5
4000	14580	1.000							652	9.40	680	10.00	740	11.4

NO. 5½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	4410	0.063	211	.32	264	.49								
1100	4850	0.076	209	.35	260	.53								
1200	5290	0.090	211	.40	260	.57	304	.78						
1300	5730	0.106	215	.45	257	.62	300	.83	340	1.06				
1400	6170	0.122	218	.52	258	.68	298	.88	336	1.12	375	1.40		
1500	6620	0.141	224	.60	260	.76	296	.95	335	1.18	371	1.45	406	1.75
1600	7060	0.160	229	.69	262	.85	298	1.04	333	1.26	367	1.52	400	1.81
1700	7500	0.180	235	.80	267	.95	300	1.13	331	1.35	366	1.60	397	1.89
1800	7940	0.202	242	.92	273	1.06	302	1.25	333	1.46	364	1.70	395	1.98
1900	8380	0.225	249	1.04	278	1.19	306	1.38	335	1.59	364	1.82	393	2.09
2000	8820	0.250	256	1.17	284	1.34	311	1.53	336	1.73	364	1.96	393	2.21
2100	9260	0.275	264	1.32	289	1.50	316	1.68	340	1.88	366	2.12	393	2.37
2200	9700	0.302	271	1.47	296	1.67	322	1.85	346	2.05	369	2.28	395	2.55
2300	10140	0.330	280	1.65	304	1.86	327	2.05	351	2.24	373	2.47	397	2.72
2400	10590	0.360	287	1.83	311	2.05	333	2.25	355	2.45	377	2.68	400	2.92
2500	11030	0.390	297	2.02	318	2.25	340	2.49	360	2.67	382	2.90	404	3.15
2600	11470	0.422	306	2.25	326	2.49	346	2.71	367	2.94	387	3.15	407	3.42
2800	12350	0.489	322	2.72	340	2.98	360	3.24	378	3.48	398	3.69	418	3.93
3000	13230	0.560	340	3.33	358	3.51	375	3.84	393	4.08	411	4.33	426	4.57
3200	14110	0.638					391	4.48	407	4.78	426	5.05	442	5.33
3400	15000	0.721									440	5.87	455	6.17

NO. 5½ NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	5730	0.106	447	1.94										
1400	6170	0.122	442	1.99	502	2.67	560	3.36						
1500	6620	0.141	437	2.07	498	2.72	555	3.48	606	4.21				
1600	7060	0.160	433	2.13	493	2.83	549	3.57	600	4.33	649	5.14		
1700	7500	0.180	427	2.20	487	2.89	544	3.66	593	4.42	642	5.29	733	7.14
1800	7940	0.202	424	2.30	482	2.99	537	3.75	587	4.54	636	5.42	726	7.26
1900	8380	0.225	422	2.39	478	3.09	533	3.84	582	4.66	631	5.54	718	7.38
2000	8820	0.250	420	2.52	476	3.21	529	3.93	576	4.78	624	5.66	711	7.53
2100	9260	0.275	420	2.65	473	3.33	524	4.08	573	4.90	618	5.81	707	7.68
2200	9700	0.302	418	2.82	471	3.45	520	4.21	567	5.02	615	5.93	702	7.84
2300	10140	0.330	420	3.00	469	3.63	518	4.36	564	5.17	611	6.08	693	7.99
2400	10590	0.360	422	3.21	469	3.78	517	4.54	560	5.35	604	6.23	689	8.17
2500	11030	0.390	424	3.45	469	4.02	515	4.72	558	5.51	602	6.41	684	8.35
2600	11470	0.422	427	3.66	471	4.24	513	4.93	557	5.72	598	6.59	680	8.53
2800	12350	0.489	437	4.21	475	4.81	515	5.48	553	6.17	595	7.05	673	8.95
3000	13230	0.560	447	4.84	482	5.42	518	6.08	557	6.78	593	7.56	669	9.47
3200	14110	0.638	456	5.54	491	6.14	524	6.78	558	7.50	595	8.29	664	10.1
3400	15000	0.721	471	6.38	502	6.93	535	7.59	564	8.29	596	9.04	662	10.8
3600	15880	0.810	482	7.32	515	7.87	544	8.50	573	9.26	604	9.95	666	11.7
3800	16760	0.900					555	9.53	582	10.2	609	11.0	669	12.7
4000	17640	1.000							593	11.4	618	12.1	673	13.8

NO. 6 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	5250	0.063	193	.37	242	.59								
1100	5770	0.076	192	.42	238	.63								
1200	6300	0.090	193	.48	238	.67	278	.93						
1300	6820	0.106	197	.54	235	.73	275	.98	312	1.27				
1400	7350	0.122	200	.62	237	.81	274	1.05	308	1.33	344	1.66		
1500	7870	0.141	205	.72	238	.91	272	1.13	307	1.41	340	1.72	372	2.08
1600	8400	0.160	210	.82	240	1.01	274	1.23	305	1.49	337	1.81	367	2.15
1700	8920	0.180	215	.95	245	1.13	275	1.35	304	1.60	335	1.91	363	2.25
1800	9450	0.202	222	1.09	250	1.26	277	1.49	305	1.73	334	2.02	362	2.36
1900	9970	0.225	228	1.24	255	1.42	280	1.64	307	1.88	334	2.16	360	2.49
2000	10500	0.250	235	1.40	260	1.59	285	1.82	309	2.06	334	2.33	360	2.63
2100	11030	0.275	242	1.57	265	1.79	290	2.00	312	2.24	335	2.52	360	2.82
2200	11550	0.302	248	1.75	272	1.98	295	2.20	317	2.43	339	2.72	362	3.04
2300	12070	0.330	257	1.96	279	2.21	300	2.43	322	2.66	342	2.94	363	3.23
2400	12600	0.360	263	2.18	285	2.45	305	2.68	325	2.92	345	3.19	367	3.48
2500	13120	0.390	272	2.41	291	2.67	312	2.96	330	3.18	350	3.45	370	3.74
2600	13650	0.422	280	2.68	299	2.96	317	3.22	337	3.50	355	3.74	374	4.07
2800	14700	0.489	295	3.24	312	3.55	330	3.85	347	4.14	365	4.39	384	4.68
3000	15750	0.560	312	3.96	329	4.18	344	4.57	360	4.86	377	5.15	390	5.44
3200	16790	0.638					359	5.33	373	5.69	390	6.01	405	6.34
3400	17850	0.721									403	6.98	417	7.35

NO. 6 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMOTER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	6820	0.106	410	2.31										
1400	7350	0.122	405	2.37	460	3.18	513	4.00						
1500	7870	0.141	400	2.46	457	3.24	509	4.14	555	5.00				
1600	8400	0.160	397	2.54	452	3.36	504	4.25	550	5.15	595	6.12		
1700	8920	0.180	392	2.62	447	3.44	499	4.36	544	5.26	589	6.30	672	8.50
1800	9450	0.202	389	2.73	442	3.56	492	4.47	539	5.40	584	6.45	665	8.64
1900	9970	0.225	387	2.85	439	3.67	489	4.57	534	5.55	579	6.59	659	8.78
2000	10500	0.250	385	3.00	437	3.82	485	4.68	529	5.69	572	6.73	652	8.96
2100	11030	0.275	385	3.16	434	3.96	480	4.86	525	5.83	567	6.91	649	9.14
2200	11550	0.302	384	3.35	432	4.11	477	5.00	520	5.98	564	7.06	644	9.32
2300	12070	0.330	385	3.57	430	4.32	475	5.18	517	6.16	560	7.24	635	9.50
2400	12600	0.360	387	3.82	430	4.50	474	5.40	514	6.37	554	7.42	632	9.72
2500	13120	0.390	389	4.10	430	4.79	472	5.62	512	6.55	552	7.63	627	9.94
2600	13650	0.422	392	4.36	432	5.04	470	5.87	510	6.81	549	7.85	624	10.2
2800	14700	0.489	400	5.00	435	5.73	472	6.52	507	7.34	545	8.39	617	10.7
3000	15750	0.560	410	5.76	442	6.45	475	7.24	510	8.06	544	9.00	614	11.3
3200	16790	0.638	419	6.59	450	7.31	480	8.06	512	8.93	545	9.86	609	12.0
3400	17850	0.721	432	7.60	460	8.24	490	9.04	517	9.86	547	10.8	607	12.8
3600	18900	0.810	442	8.71	472	9.36	499	10.1	525	11.0	554	11.9	610	13.9
3800	19950	0.900					509	11.3	534	12.2	559	13.1	614	15.1
4000	21000	1.000							544	13.5	567	14.4	617	16.4

NO. 7 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H.P.
1000	7140	0.063	166	0.51	207	0.80								
1100	7860	0.076	164	0.57	204	0.85								
1200	8570	0.090	166	0.65	204	0.92	239	1.26						
1300	9290	0.106	169	0.74	202	1.00	236	1.34	267	1.73				
1400	10000	0.122	172	0.85	203	1.10	234	1.43	264	1.81	294	2.26		
1500	10720	0.141	176	0.98	204	1.24	233	1.53	263	1.91	292	2.34	319	2.83
1600	11430	0.160	180	1.12	206	1.37	234	1.68	262	2.03	289	2.46	314	2.93
1700	12150	0.180	184	1.29	210	1.54	236	1.83	260	2.18	287	2.60	312	3.07
1800	12860	0.202	190	1.49	214	1.72	237	2.02	262	2.36	286	2.75	310	3.21
1900	13570	0.225	196	1.68	219	1.93	240	2.23	263	2.56	286	2.95	309	3.39
2000	14290	0.250	202	1.90	223	2.17	244	2.47	264	2.80	286	3.18	309	3.58
2100	15000	0.275	207	2.13	227	2.44	249	2.73	267	3.05	287	3.43	309	3.84
2200	15720	0.302	213	2.38	233	2.70	253	3.00	272	3.31	290	3.70	310	4.13
2300	16430	0.330	220	2.67	239	3.01	257	3.31	276	3.63	293	4.00	312	4.40
2400	17150	0.360	226	2.97	244	3.33	262	3.64	279	3.97	296	4.34	314	4.73
2500	17860	0.390	233	3.27	250	3.64	267	4.03	283	4.33	300	4.70	317	5.10
2600	18580	0.422	240	3.64	256	4.03	272	4.39	289	4.77	304	5.10	320	5.54
2800	20000	0.489	253	4.41	267	4.83	283	5.24	297	5.64	313	5.98	329	6.37
3000	21430	0.560	267	5.39	282	5.68	294	6.22	309	6.62	323	7.01	334	7.40
3200	22860	0.638					307	7.25	320	7.74	334	8.18	347	8.62
3400	24290	0.721									346	9.51	357	10.0

NO. 7 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	9290	0.106	352	3.14										
1400	10000	0.122	347	3.23	394	4.33	440	5.44						
1500	10720	0.141	343	3.35	392	4.41	436	5.64	476	6.81				
1600	11430	0.160	340	3.46	387	4.58	432	5.78	472	7.01	510	8.33		
1700	12150	0.180	336	3.57	383	4.68	427	5.93	466	7.15	504	8.58	576	11.6
1800	12860	0.202	333	3.72	379	4.85	422	6.08	462	7.35	500	8.77	570	11.8
1900	13570	0.225	332	3.88	376	5.00	419	6.22	457	7.55	496	8.97	564	12.0
2000	14290	0.250	330	4.08	374	5.19	416	6.37	453	7.74	490	9.16	559	12.2
2100	15000	0.275	330	4.30	372	5.39	412	6.62	450	7.94	486	9.41	556	12.5
2200	15720	0.302	329	4.56	370	5.59	409	6.81	446	8.13	483	9.60	552	12.7
2300	16430	0.330	330	4.86	369	5.88	407	7.06	443	8.38	480	9.85	544	12.9
2400	17150	0.360	332	5.19	369	6.13	406	7.35	440	8.67	474	10.1	542	13.2
2500	17860	0.390	333	5.59	369	6.52	404	7.64	439	8.92	473	10.4	537	13.5
2600	18580	0.422	336	5.93	370	6.86	403	7.99	437	9.26	470	10.7	534	13.8
2800	20000	0.489	343	6.81	373	7.79	404	8.87	434	10.0	467	11.4	529	14.5
3000	21430	0.560	352	7.84	379	8.77	407	9.85	437	11.0	466	12.3	526	15.3
3200	22860	0.638	359	8.97	386	9.95	412	11.0	439	12.2	467	13.4	522	16.3
3400	24290	0.721	370	10.3	394	11.2	420	12.3	443	13.4	469	14.7	520	17.4
3600	25720	0.810	379	11.9	404	12.7	427	13.8	450	15.0	474	16.1	523	18.9
3800	27150	0.900					436	15.4	457	16.6	479	17.8	526	20.5
4000	28580	1.000							466	18.4	486	19.6	529	22.4

NO. 8 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	9330	0.063	145	.67	181	1.04								
1100	10270	0.076	144	.74	179	1.11								
1200	11200	0.090	145	.85	179	1.20	209	1.65						
1300	12130	0.106	148	.96	176	1.31	206	1.75	234	2.25				
1400	13060	0.122	150	1.11	178	1.44	205	1.87	231	2.36	258	2.95		
1500	14000	0.141	154	1.27	179	1.61	204	2.00	230	2.50	255	3.06	279	3.69
1600	14930	0.160	158	1.47	180	1.79	205	2.19	229	2.66	253	3.21	275	3.82
1700	15860	0.180	161	1.69	184	2.01	206	2.39	228	2.85	251	3.39	273	4.01
1800	16800	0.202	166	1.94	188	2.25	208	2.64	229	3.08	250	3.59	271	4.19
1900	17730	0.225	171	2.20	191	2.52	210	2.91	230	3.34	250	3.85	270	4.42
2000	18660	0.250	176	2.48	195	2.83	214	3.23	231	3.66	250	4.15	270	4.68
2100	19600	0.275	181	2.79	199	3.18	218	3.56	234	3.98	251	4.48	270	5.02
2200	20530	0.302	186	3.11	204	3.53	221	3.92	238	4.33	254	4.83	271	5.40
2300	21460	0.330	193	3.48	209	3.93	225	4.33	241	4.74	256	5.22	273	5.75
2400	22400	0.360	198	3.87	214	4.35	229	4.76	244	5.19	259	5.67	275	6.18
2500	23330	0.390	204	4.28	219	4.75	234	5.26	248	5.65	263	6.13	278	6.66
2600	24260	0.422	210	4.76	224	5.26	238	5.73	253	6.23	266	6.66	280	7.23
2800	26130	0.489	221	5.76	234	6.31	248	6.85	260	7.36	274	7.81	288	8.32
3000	28000	0.560	234	7.04	246	7.42	258	8.13	270	8.64	283	9.15	293	9.66
3200	29860	0.638					269	9.47	280	10.1	293	10.7	304	11.3
3400	31720	0.721									303	12.4	313	13.1

NO. 8 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	12130	0.106	308	4.10										
1400	13060	0.122	304	4.22	345	5.65	385	7.10						
1500	14000	0.141	300	4.37	343	5.76	381	7.36	416	8.90				
1600	14930	0.160	298	4.51	339	5.98	378	7.55	413	9.15	446	10.9		
1700	15860	0.180	294	4.66	335	6.11	374	7.74	408	9.34	441	11.2	504	15.1
1800	16800	0.202	291	4.86	331	6.33	369	7.94	404	9.60	438	11.5	499	15.4
1900	17730	0.225	290	5.06	329	6.53	366	8.13	400	9.86	434	11.7	494	15.6
2000	18660	0.250	289	5.33	328	6.78	364	8.32	396	10.1	429	12.0	489	15.9
2100	19600	0.275	289	5.61	325	7.04	360	8.64	394	10.4	425	12.3	486	16.3
2200	20530	0.302	288	5.96	324	7.30	358	8.90	390	10.6	423	12.6	483	16.6
2300	21460	0.330	289	6.35	323	7.68	356	9.22	388	11.0	420	12.9	476	16.9
2400	22400	0.360	290	6.78	323	8.00	355	9.60	385	11.3	415	13.2	474	17.3
2500	23330	0.390	291	7.30	323	8.51	354	9.98	384	11.7	414	13.6	470	17.7
2600	24260	0.422	294	7.74	324	8.96	353	10.4	383	12.1	411	14.0	468	18.1
2800	26130	0.489	300	8.90	326	10.2	354	11.6	380	13.1	409	14.9	463	19.0
3000	28000	0.560	308	10.2	331	11.5	356	12.9	383	14.3	408	16.0	460	20.0
3200	29860	0.638	314	11.7	338	13.0	360	14.3	384	15.9	409	17.5	456	21.3
3400	31720	0.721	324	13.5	345	14.7	368	16.1	388	17.5	410	19.1	455	22.8
3600	33590	0.810	331	15.5	354	16.6	374	18.0	394	19.6	415	21.1	458	24.7
3800	35460	0.900					381	20.2	400	21.6	419	23.3	460	26.8
4000	37330	1.000							408	24.1	425	25.6	463	29.2

NO. 9 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1000	11810	0.063	129	0.84	161	1.32								
1100	12990	0.076	128	0.94	159	1.41								
1200	14170	0.090	129	1.07	159	1.52	186	2.09						
1300	15360	0.106	131	1.22	157	1.65	183	2.21	208	2.85				
1400	16530	0.122	133	1.40	158	1.82	182	2.37	206	2.99	229	3.74		
1500	17720	0.141	137	1.61	159	2.04	181	2.54	205	3.16	227	3.87	248	4.67
1600	18900	0.160	140	1.86	160	2.27	182	2.77	203	3.36	225	4.07	244	4.84
1700	20080	0.180	143	2.14	163	2.54	183	3.03	202	3.60	223	4.29	242	5.07
1800	21250	0.202	148	2.45	167	2.84	185	3.35	203	3.90	222	4.55	241	5.30
1900	22440	0.225	152	2.78	170	3.19	187	3.69	205	4.23	222	4.87	240	5.60
2000	23620	0.250	157	3.14	173	3.58	190	4.08	206	4.64	222	5.25	240	5.92
2100	24800	0.275	161	3.52	177	4.03	193	4.51	208	5.04	223	5.67	240	6.35
2200	25980	0.302	166	3.93	181	4.47	197	4.96	211	5.47	226	6.10	241	6.83
2300	27160	0.330	171	4.41	186	4.97	200	5.48	215	6.00	228	6.61	242	7.27
2400	28340	0.360	176	4.90	190	5.50	203	6.02	217	6.56	230	7.18	244	7.82
2500	29520	0.390	181	5.41	195	6.01	208	6.66	220	7.15	233	7.76	247	8.43
2600	30710	0.422	187	6.02	199	6.66	211	7.25	224	7.88	237	8.42	249	9.15
2800	33070	0.489	197	7.28	208	7.98	220	8.67	231	9.30	243	9.88	256	10.5
3000	35430	0.560	208	8.91	219	9.40	229	10.3	240	10.9	251	11.6	260	12.2
3200	37790	0.638					239	12.0	249	12.8	260	13.5	270	14.3
3400	40150	0.721									269	15.7	278	16.5

NO. 9 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1300	15360	0.106	273	5.18										
1400	16530	0.122	270	5.34	307	7.15	342	8.99						
1500	17720	0.141	267	5.53	304	7.29	339	9.31	370	11.3				
1600	18900	0.160	264	5.71	301	7.57	336	9.56	367	11.6	397	13.8		
1700	20080	0.180	261	5.90	298	7.73	332	9.80	362	11.8	392	14.2	448	19.1
1800	21250	0.202	259	6.15	294	8.01	328	10.0	359	12.2	389	14.5	443	19.4
1900	22440	0.225	258	6.41	292	8.26	326	10.3	356	12.5	386	14.8	439	19.8
2000	23620	0.250	257	6.74	291	8.59	323	10.5	352	12.8	381	15.2	435	20.2
2100	24800	0.275	257	7.10	289	8.91	320	10.9	350	13.1	378	15.6	432	20.6
2200	25980	0.302	256	7.54	288	9.23	318	11.3	347	13.4	376	15.9	429	21.0
2300	27160	0.330	257	8.04	287	9.72	317	11.7	344	13.7	373	16.3	423	21.4
2400	28340	0.360	258	8.59	287	10.1	316	12.2	342	14.3	369	16.7	421	21.9
2500	29520	0.390	259	9.23	287	10.8	314	12.6	341	14.8	368	17.2	418	22.4
2600	30710	0.422	261	9.80	288	11.3	313	13.2	340	15.3	366	17.7	416	22.8
2800	33070	0.489	267	11.3	290	12.9	314	14.7	338	16.5	363	18.9	411	24.0
3000	35430	0.560	273	13.0	294	14.5	317	16.3	340	18.2	362	20.3	409	25.4
3200	37790	0.638	279	14.8	300	16.4	320	18.1	341	20.1	363	22.2	406	27.0
3400	40150	0.721	288	17.1	307	18.6	327	20.3	344	22.2	364	24.2	405	28.8
3600	42510	0.810	294	19.6	314	21.1	332	22.8	350	24.8	369	26.7	407	31.3
3800	44880	0.900					339	25.5	356	27.4	372	29.5	409	33.9
4000	47240	1.000							362	30.5	378	32.4	411	36.9

NO. 10 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	14580	0.063	116	1.04	145	1.63								
1100	16040	0.076	115	1.16	143	1.74								
1200	17500	0.090	116	1.32	143	1.87	167	2.58						
1300	18960	0.106	118	1.50	141	2.04	165	2.73	187	3.52				
1400	20410	0.122	120	1.73	142	2.25	164	2.92	185	3.69	206	4.61		
1500	21870	0.141	123	1.99	143	2.52	163	3.13	184	3.90	204	4.78	223	5.77
1600	23330	0.160	126	2.29	144	2.80	164	3.42	183	4.15	202	5.02	220	5.97
1700	24790	0.180	129	2.64	147	3.14	165	3.74	182	4.45	201	5.30	218	6.26
1800	26240	0.202	133	3.03	150	3.51	166	4.13	183	4.81	200	5.61	217	6.55
1900	27700	0.225	137	3.43	153	3.94	168	4.55	184	5.22	200	6.01	216	6.91
2000	29160	0.250	141	3.88	156	4.42	171	5.04	185	5.72	200	6.48	216	7.31
2100	30620	0.275	145	4.35	159	4.97	174	5.56	187	6.22	201	7.00	216	7.84
2200	32080	0.302	149	4.85	163	5.51	177	6.12	190	6.76	203	7.54	217	8.43
2300	33540	0.330	154	5.44	167	6.14	180	6.76	193	7.40	205	8.16	218	8.98
2400	34990	0.360	158	6.05	171	6.79	183	7.43	195	8.10	207	8.86	220	9.65
2500	36450	0.390	163	6.68	175	7.42	187	8.22	198	8.83	210	9.58	222	10.4
2600	37910	0.422	168	7.43	179	8.22	190	8.95	202	9.73	213	10.4	224	11.3
2800	40830	0.489	177	8.99	187	9.85	198	10.7	208	11.5	219	12.2	230	13.0
3000	43740	0.560	187	11.0	197	11.6	206	12.7	216	13.5	226	14.3	234	15.1
3200	46660	0.638					215	14.8	224	15.8	234	16.7	243	17.6
3400	49570	0.721									242	19.4	250	20.4

NO. 10 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1300	18960	0.106	246	6.40										
1400	20410	0.122	243	6.59	276	8.83	308	11.1						
1500	21870	0.141	240	6.83	274	9.00	305	11.5	333	13.9				
1600	23330	0.160	238	7.05	271	9.34	302	11.8	330	14.3	357	17.0		
1700	24790	0.180	235	7.28	268	9.54	299	12.1	326	14.6	353	17.5	403	23.6
1800	26240	0.202	233	7.59	265	9.89	295	12.4	323	15.0	350	17.9	399	24.0
1900	27700	0.225	232	7.91	263	10.2	293	12.7	320	15.4	347	18.3	395	24.4
2000	29160	0.250	231	8.32	262	10.6	291	13.0	317	15.8	343	18.7	391	24.9
2100	30620	0.275	231	8.77	260	11.0	288	13.5	315	16.2	340	19.2	389	25.4
2200	32080	0.302	230	9.31	259	11.4	286	13.9	312	16.6	338	19.6	386	25.9
2300	33540	0.330	231	9.92	258	12.0	285	14.4	310	17.1	336	20.1	381	26.4
2400	34990	0.360	232	10.6	258	12.5	284	15.0	308	17.7	332	20.6	379	27.0
2500	36450	0.390	233	11.4	258	13.3	283	15.6	307	18.2	331	21.2	376	27.6
2600	37910	0.422	235	12.1	259	14.0	282	16.3	306	18.9	329	21.8	374	28.2
2800	40830	0.489	240	13.9	261	15.9	283	18.1	304	20.4	327	23.3	370	29.6
3000	43740	0.560	246	16.0	265	17.9	285	20.1	306	22.4	326	25.0	368	31.3
3200	46660	0.638	251	18.3	270	20.3	288	22.4	307	24.8	327	27.4	365	33.3
3400	49570	0.721	259	21.1	276	22.9	294	25.1	310	27.4	328	29.9	364	35.6
3600	52490	0.810	265	24.2	283	26.0	299	28.1	315	30.6	332	32.9	366	38.6
3800	55400	0.900					305	31.5	320	33.8	335	36.4	368	41.8
4000	58320	1.000							326	37.6	340	40.0	370	45.6

NO. 11 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	17640	0.063	106	1.26	132	1.97								
1100	19410	0.076	105	1.40	130	2.11								
1200	21170	0.090	106	1.60	130	2.26	152	3.12						
1300	22930	0.106	107	1.82	128	2.47	150	3.30	170	4.26				
1400	24700	0.122	109	2.09	129	2.72	149	3.53	168	4.47	187	5.58		
1500	26460	0.141	112	2.41	130	3.05	148	3.79	167	4.72	186	5.78	203	6.98
1600	28230	0.160	115	2.77	131	3.39	149	4.14	166	5.02	184	6.08	200	7.22
1700	29990	0.180	117	3.20	134	3.80	150	4.53	166	5.39	183	6.41	198	7.58
1800	31750	0.202	121	3.67	136	4.25	151	5.00	166	5.82	182	6.79	197	7.93
1900	33520	0.225	125	4.15	139	4.77	153	5.51	167	6.32	182	7.27	196	8.36
2000	35280	0.250	128	4.70	142	5.35	156	6.10	168	6.92	182	7.84	196	8.85
2100	37050	0.275	132	5.26	145	6.01	158	6.73	170	7.53	183	8.87	196	9.49
2200	38810	0.302	136	5.87	148	6.67	161	7.41	173	8.18	185	9.12	197	10.2
2300	40580	0.330	140	6.58	152	7.43	164	8.18	176	8.95	186	9.87	198	10.9
2400	42340	0.360	144	7.32	156	8.22	166	8.99	177	9.80	188	10.7	200	11.7
2500	44100	0.390	148	8.08	159	8.98	170	9.95	180	10.7	191	11.6	202	12.6
2600	45870	0.422	153	8.99	163	9.95	173	10.8	184	11.8	194	12.6	204	13.7
2800	49400	0.489	161	10.9	170	11.9	180	13.0	189	13.9	199	14.8	209	15.7
3000	52910	0.560	170	13.3	179	14.0	187	15.4	196	16.3	206	17.3	213	18.3
3200	56450	0.638					196	17.9	204	19.1	213	20.2	221	21.3
3400	59980	0.721									220	23.5	227	24.7

NO. 11 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	22930	0.106	224	7.74										
1400	24700	0.122	221	7.97	251	10.7	280	13.4						
1500	26460	0.141	218	8.26	249	10.9	277	13.9	303	16.8				
1600	28230	0.160	216	8.53	246	11.3	275	14.3	300	17.3	325	20.6		
1700	29990	0.180	214	8.81	244	11.6	272	14.7	296	17.7	321	21.2	366	28.6
1800	31750	0.202	212	9.18	241	12.0	268	15.0	294	18.2	318	21.7	363	29.0
1900	33520	0.225	211	9.57	239	12.4	266	15.4	291	18.6	316	22.2	359	29.5
2000	35280	0.250	210	10.1	238	12.8	265	15.7	288	19.1	312	22.6	356	30.1
2100	37050	0.275	210	10.6	236	13.3	262	16.3	286	19.6	309	23.2	354	30.7
2200	38810	0.302	209	11.3	236	13.8	260	16.8	284	20.1	307	23.7	351	31.3
2300	40580	0.330	210	12.0	235	14.5	259	17.4	282	20.7	306	24.3	346	32.0
2400	42340	0.360	211	12.8	235	15.1	258	18.2	280	21.4	302	24.9	345	32.7
2500	44100	0.390	212	13.8	235	16.1	257	18.9	279	22.0	301	25.7	342	33.4
2600	45870	0.422	214	14.6	236	17.0	256	19.7	278	22.9	299	26.4	340	34.1
2800	49400	0.489	218	16.8	237	19.2	257	21.9	276	24.7	297	28.2	336	35.8
3000	52910	0.560	224	19.4	241	21.7	259	24.3	278	27.1	296	30.3	335	37.9
3200	56450	0.638	228	22.1	246	24.6	262	27.1	279	30.0	297	33.2	332	40.3
3400	59980	0.721	236	25.5	251	27.7	267	30.4	282	33.2	248	36.2	331	43.1
3600	63510	0.810	241	29.3	257	31.5	272	34.0	286	37.0	302	39.8	333	46.7
3800	67030	0.900					277	38.1	291	40.9	305	44.1	335	50.6
4000	70560	1.000							296	45.5	309	48.4	336	55.2

NO. 12 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	21000	0.063	97	1.50	121	2.35								
1100	23090	0.076	96	1.67	119	2.51								
1200	25190	0.090	97	1.90	119	2.69	139	3.72						
1300	27290	0.106	98	2.16	118	2.94	138	3.93	156	5.07				
1400	29390	0.122	100	2.49	118	3.24	137	4.21	154	5.31	172	6.64		
1500	31490	0.141	103	2.87	119	3.63	136	4.51	153	5.62	170	6.88	186	8.31
1600	33600	0.160	105	3.30	120	4.03	137	4.93	153	5.98	168	7.23	183	8.60
1700	35690	0.180	108	3.80	123	4.52	138	5.39	152	6.41	168	7.63	182	9.02
1800	37790	0.202	111	4.36	125	5.06	138	5.95	153	6.93	167	8.08	181	9.43
1900	39890	0.225	114	4.94	128	5.67	140	6.55	153	7.52	167	8.66	180	9.95
2000	41990	0.250	118	5.59	130	6.37	143	7.26	154	8.24	167	9.33	180	10.5
2100	44090	0.275	121	6.27	133	7.16	145	8.01	156	8.96	168	10.1	180	11.3
2200	46190	0.302	124	6.99	136	7.94	148	8.81	158	9.74	169	10.9	181	12.2
2300	48290	0.330	128	7.83	139	8.84	150	9.74	161	10.7	171	11.8	182	12.9
2400	50390	0.360	132	8.71	143	9.78	153	10.7	163	11.7	173	12.8	183	13.9
2500	52490	0.390	136	9.62	146	10.7	156	11.8	165	12.7	175	13.8	185	15.0
2600	54590	0.422	140	10.7	149	11.8	158	12.9	168	14.0	178	15.0	187	16.3
2800	58790	0.489	148	13.0	156	14.2	165	15.4	173	16.6	183	17.6	192	18.7
3000	62980	0.560	156	15.9	164	16.7	172	18.3	180	19.5	188	20.6	195	21.8
3200	67180	0.638					179	21.3	187	22.8	195	24.1	203	25.4
3400	71380	0.721									202	27.9	208	29.4

NO. 12 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	27290	0.106	205	9.22										
1400	29390	0.122	203	9.49	230	12.7	257	16.0						
1500	31490	0.141	200	9.84	228	13.0	254	16.6	278	20.0				
1600	33600	0.160	198	10.2	226	13.5	252	17.0	275	20.6	298	24.5		
1700	35690	0.180	196	10.5	223	13.7	249	17.4	272	21.0	294	25.2	336	34.0
1800	37790	0.202	194	10.9	221	14.3	246	17.9	269	21.6	292	25.8	333	34.6
1900	39890	0.225	193	11.4	219	14.7	244	18.3	267	22.2	289	26.4	329	35.1
2000	41990	0.250	193	12.0	218	15.3	243	18.7	264	22.8	286	26.9	326	35.9
2100	44090	0.275	193	12.6	217	15.8	240	19.5	263	23.3	283	27.7	324	36.6
2200	46190	0.302	192	13.4	216	16.4	238	20.0	260	23.9	282	28.2	322	37.3
2300	48290	0.330	193	14.3	215	17.3	238	20.7	258	24.6	280	29.0	318	38.0
2400	50390	0.360	193	15.3	215	18.0	237	21.6	257	25.5	277	29.7	316	38.9
2500	52490	0.390	194	16.4	215	19.2	236	22.5	256	26.2	276	30.5	313	39.8
2600	54590	0.422	196	17.4	216	20.2	235	23.5	255	27.2	274	31.4	312	40.6
2800	58790	0.489	200	20.0	218	22.9	236	26.1	253	29.4	273	33.6	308	42.6
3000	62980	0.560	205	23.0	221	25.8	238	29.0	255	32.3	272	36.0	307	45.1
3200	67180	0.638	209	26.4	225	29.2	240	32.3	256	35.7	273	39.5	304	48.0
3400	71380	0.721	216	30.4	230	33.0	245	36.2	258	39.5	273	43.1	303	51.3
3600	75580	0.810	221	34.9	236	37.5	249	40.5	263	44.1	277	47.4	305	55.6
3800	79780	0.900					254	45.4	267	48.7	279	52.4	307	60.2
4000	83980	1.000							272	54.2	283	57.6	308	65.7

NO. 13 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	24650	0.063	89	1.76	112	2.76								
1100	27110	0.076	89	1.96	110	2.94								
1200	29570	0.090	89	2.23	110	3.16	129	4.36						
1300	32040	0.106	91	2.54	109	3.45	127	4.61	144	5.95				
1400	34500	0.122	92	2.92	109	3.80	126	4.94	142	6.24	159	7.79		
1500	36960	0.141	95	3.36	110	4.26	125	5.29	142	6.59	157	8.08	172	9.75
1600	39430	0.160	97	3.87	111	4.73	126	5.78	141	7.01	156	8.48	169	10.1
1700	41900	0.180	99	4.46	113	5.31	127	6.32	140	7.52	155	8.96	168	10.6
1800	44350	0.202	102	5.12	115	5.93	128	6.98	141	8.13	154	9.48	167	11.1
1900	46810	0.225	105	5.80	118	6.66	129	7.69	142	8.82	154	10.2	166	11.7
2000	49280	0.250	109	6.56	120	7.47	132	8.52	142	9.67	154	11.0	166	12.4
2100	51740	0.275	112	7.35	122	8.40	134	9.40	144	10.5	155	11.8	166	13.3
2200	54210	0.302	115	8.20	125	9.31	136	10.4	146	11.4	156	12.8	167	14.3
2300	56680	0.330	119	9.19	129	10.4	139	11.4	149	12.5	158	13.8	168	15.2
2400	59130	0.360	122	10.2	132	11.5	141	12.6	150	13.7	159	15.0	169	16.3
2500	61600	0.390	125	11.3	135	12.6	144	13.9	152	14.9	162	16.2	171	17.6
2600	64060	0.422	129	12.6	138	13.9	146	15.1	156	16.5	164	17.6	172	19.1
2800	69000	0.489	136	15.2	144	16.7	152	18.1	160	19.4	169	20.6	177	22.0
3000	73920	0.560	144	18.6	152	19.6	159	21.5	166	22.8	174	24.2	180	25.5
3200	78850	0.638					166	25.0	172	26.7	180	28.2	187	29.8
3400	83770	0.721									186	32.8	192	34.5

NO. 13 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1300	32040	0.106	189	10.8										
1400	34500	0.122	187	11.1	212	14.9	237	18.8						
1500	36960	0.141	185	11.6	211	15.2	235	19.4	256	23.5				
1600	39430	0.160	183	11.9	209	15.8	232	20.0	254	24.2	275	28.7		
1700	41900	0.180	181	12.3	206	16.1	230	20.5	251	24.7	272	29.6	310	39.9
1800	44350	0.202	179	12.8	204	16.7	227	21.0	249	25.4	269	30.3	307	40.6
1900	46810	0.225	179	13.4	202	17.2	225	21.5	246	26.0	267	30.9	304	41.2
2000	49280	0.250	178	14.1	202	17.9	224	22.0	244	26.7	264	31.6	301	42.1
2100	51740	0.275	178	14.8	200	18.6	222	22.8	242	27.4	262	32.5	299	42.9
2200	54210	0.302	177	15.7	199	19.3	220	23.5	240	28.1	260	33.1	297	43.8
2300	56680	0.330	178	16.8	199	20.3	219	24.3	239	28.9	259	34.0	293	44.6
2400	59130	0.360	179	17.9	199	21.1	219	25.4	237	29.9	255	34.8	292	45.6
2500	61600	0.390	179	19.3	199	22.5	218	26.4	236	30.8	255	35.8	289	46.7
2600	64060	0.422	181	20.5	199	23.7	217	27.6	235	31.9	253	36.8	288	47.7
2800	69000	0.489	185	23.5	201	26.9	218	30.6	234	34.5	252	39.4	285	50.0
3000	73920	0.560	189	27.0	204	30.3	219	34.0	235	37.9	251	42.3	283	52.9
3200	78850	0.638	193	30.9	208	34.3	222	37.9	236	41.9	252	46.3	281	56.3
3400	83770	0.721	199	35.7	212	38.7	226	42.4	239	46.3	252	50.5	280	60.2
3600	88700	0.810	204	40.9	218	44.0	230	47.5	242	51.7	255	55.6	282	65.2
3800	93620	0.900					235	53.2	246	57.1	258	61.5	283	70.6
4000	98560	1.000							251	63.5	262	67.6	285	77.1

NO. 14 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	28680	0.063	83	2.04	104	3.20								
1100	31440	0.076	82	2.27	102	3.41								
1200	34290	0.090	83	2.59	102	3.67	119	5.06						
1300	37150	0.106	84	2.94	101	4.00	118	5.35	134	6.90				
1400	40000	0.122	86	3.39	102	4.41	117	5.72	132	7.23	147	9.04		
1500	42860	0.141	88	3.90	102	4.94	117	6.14	132	7.65	146	9.37	159	11.3
1600	45720	0.160	90	4.49	103	5.49	117	6.70	131	8.14	144	9.84	157	11.7
1700	48580	0.180	92	5.18	105	6.16	118	7.33	130	8.72	144	10.4	156	12.3
1800	51420	0.202	95	5.94	107	6.88	119	8.10	131	9.43	143	11.0	155	12.8
1900	54290	0.225	98	6.72	109	7.72	120	8.92	132	10.2	143	11.8	154	13.6
2000	57150	0.250	101	7.61	112	8.66	122	9.88	132	11.2	143	12.7	154	14.3
2100	60010	0.275	104	8.53	114	9.74	124	10.9	134	12.2	144	13.7	154	15.4
2200	62880	0.302	107	9.51	117	10.8	127	12.0	136	13.3	145	14.8	155	16.5
2300	65720	0.330	110	10.7	119	12.0	129	13.3	138	14.5	147	16.0	156	17.6
2400	68580	0.360	113	11.9	122	13.3	131	14.6	139	15.9	148	17.4	157	18.9
2500	71430	0.390	117	13.1	125	14.6	134	16.1	142	17.3	150	18.8	159	20.4
2600	74290	0.432	120	14.6	128	16.1	136	17.6	144	19.1	152	20.4	160	22.2
2800	80010	0.489	127	17.6	134	19.3	142	21.0	149	22.6	157	23.9	164	25.5
3000	85730	0.560	134	21.6	141	22.7	147	24.9	154	26.5	162	28.0	167	29.6
3200	91440	0.638					154	29.0	160	31.0	167	32.7	174	34.5
3400	97150	0.721									173	38.0	179	40.0

NO. 14 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H.P.
1300	37150	0.106	176	12.6										
1400	40000	0.122	174	12.9	197	17.3	220	21.8						
1500	42860	0.141	172	13.4	196	17.7	218	22.6	238	27.3				
1600	45720	0.160	170	13.8	194	18.3	216	23.1	236	28.0	255	33.3		
1700	48580	0.180	168	14.3	192	18.7	214	23.7	233	28.6	252	34.3	288	46.3
1800	51420	0.202	167	14.9	189	19.4	211	24.3	231	29.4	250	35.1	285	47.1
1900	54290	0.225	166	15.5	188	20.0	209	24.9	229	30.2	248	35.9	282	47.8
2000	57150	0.250	165	16.3	187	20.8	208	25.5	227	31.0	245	36.7	279	48.8
2100	60010	0.275	165	17.2	186	21.6	206	26.5	225	31.8	243	37.6	278	49.8
2200	62880	0.302	164	18.3	185	22.4	204	27.3	223	32.5	242	38.4	276	50.8
2300	65720	0.330	165	19.5	184	23.5	204	28.2	222	33.5	240	39.4	272	51.8
2400	68580	0.360	166	20.8	184	24.5	203	29.4	220	34.7	237	40.4	271	52.9
2500	71430	0.390	167	22.4	184	26.1	202	30.6	219	35.7	237	41.6	269	54.1
2600	74290	0.432	168	23.7	185	27.5	202	32.0	219	37.1	235	42.7	267	55.3
2800	80010	0.489	172	27.3	187	31.2	202	35.5	217	40.0	234	45.7	264	58.0
3000	85730	0.560	176	31.4	189	35.1	204	39.4	219	43.9	233	49.0	263	61.4
3200	91440	0.638	179	35.9	193	39.8	206	43.9	219	48.6	234	53.7	261	65.3
3400	97150	0.721	185	41.4	197	44.9	210	49.2	222	53.7	234	58.6	260	69.8
3600	102870	0.810	189	47.4	202	51.0	214	55.1	225	60.0	237	64.5	262	75.7
3800	108580	0.900					218	61.8	229	66.3	239	71.4	263	81.9
4000	114290	1.000							233	73.7	243	78.4	264	89.4

NO. 15 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H.P.
1000	32800	0.063	77	2.34	97	3.67								
1100	36080	0.076	77	2.61	95	3.92								
1200	39360	0.090	77	2.97	95	4.21	111	5.81						
1300	42650	0.106	79	3.38	94	4.59	110	6.14	125	7.92				
1400	45920	0.122	80	3.89	95	5.06	109	6.57	123	8.30	137	10.4		
1500	49210	0.141	82	4.48	95	5.67	109	7.04	123	8.78	136	10.8	149	13.0
1600	52490	0.160	84	5.15	96	6.30	109	7.70	122	9.34	135	11.3	147	13.4
1700	55760	0.180	86	5.94	98	7.07	110	8.42	121	10.0	134	11.9	145	14.1
1800	59040	0.202	89	6.82	100	7.90	111	9.29	122	10.8	133	12.6	145	14.7
1900	62320	0.225	91	7.72	102	8.87	112	10.2	123	11.8	133	13.5	144	15.6
2000	65610	0.250	94	8.73	104	9.95	114	11.4	123	12.9	133	14.6	144	16.5
2100	68900	0.275	97	9.79	106	11.2	116	12.5	125	14.0	134	15.8	144	17.7
2200	72160	0.302	99	10.9	109	12.4	118	13.8	127	15.2	135	17.0	145	19.0
2300	75450	0.330	103	12.2	111	13.8	120	15.2	129	16.7	137	18.4	145	20.2
2400	78720	0.360	105	13.6	114	15.3	122	16.7	130	18.2	138	19.9	147	21.7
2500	82010	0.390	109	15.0	117	16.7	125	18.5	132	19.9	140	21.6	148	23.4
2600	85300	0.432	112	16.7	119	18.5	127	20.1	135	21.9	142	23.4	149	25.4
2800	91850	0.489	118	20.2	125	22.2	132	24.1	139	25.9	146	27.5	153	29.3
3000	98420	0.560	125	24.8	131	26.1	137	28.6	144	30.4	151	32.2	156	34.0
3200	104970	0.638					143	33.3	149	35.6	156	37.6	162	39.6
3400	111520	0.721									161	43.7	167	45.9

NO. 15 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	42650	0.106	164	14.4										
1400	45920	0.122	162	14.8	184	19.9	205	25.0						
1500	49210	0.141	160	15.4	183	20.3	203	25.9	222	31.3				
1600	52490	0.160	159	15.9	181	21.0	201	26.6	220	32.2	238	38.3		
1700	55760	0.180	157	16.4	179	21.5	199	27.2	217	32.9	235	39.4	269	53.1
1800	59040	0.202	155	17.1	177	22.3	197	27.9	215	33.8	233	40.3	266	54.0
1900	62320	0.225	155	17.8	175	23.0	195	28.6	213	34.7	231	41.2	263	54.9
2000	65610	0.250	154	18.7	175	23.9	194	29.3	211	35.6	229	42.1	261	56.0
2100	68900	0.275	154	19.7	173	24.8	192	30.4	210	36.5	227	43.2	259	57.2
2200	72160	0.302	153	21.0	173	25.7	191	31.3	208	37.4	225	44.1	257	58.3
2300	75450	0.330	154	22.3	172	27.0	190	32.4	207	38.5	224	45.2	254	59.4
2400	78720	0.360	155	23.8	172	28.1	189	33.8	205	39.8	221	46.4	253	60.8
2500	82010	0.390	155	25.7	172	29.9	189	35.1	205	41.0	221	47.7	251	62.1
2600	85300	0.422	157	27.2	173	31.5	188	36.7	204	42.5	219	49.1	249	63.5
2800	91850	0.489	160	31.3	174	35.8	189	40.7	203	45.9	218	52.4	247	66.6
3000	98420	0.560	164	36.0	177	40.3	190	45.2	204	50.4	217	56.3	245	70.4
3200	104970	0.638	167	41.2	180	45.7	192	50.4	205	55.8	218	61.7	243	74.9
3400	111520	0.721	173	47.5	184	51.5	196	56.5	207	61.7	219	67.3	243	80.1
3600	118100	0.810	177	54.5	189	58.5	199	63.2	210	68.9	221	74.0	244	86.9
3800	124650	0.900					203	70.9	213	76.1	223	81.9	245	94.1
4000	131210	1.000							217	84.6	227	90.0	247	102.6

NO. 16 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	37320	0.063	73	2.66	91	4.17								
1100	41060	0.076	72	2.97	89	4.46								
1200	44790	0.090	73	3.38	89	4.79	104	6.61						
1300	48520	0.106	74	3.84	88	5.22	103	6.99	117	9.01				
1400	52250	0.122	75	4.43	89	5.76	103	7.48	116	9.45	129	11.8		
1500	55980	0.141	77	5.10	89	6.45	102	8.01	115	9.98	128	12.2	139	14.8
1600	59720	0.160	79	5.86	90	7.17	103	8.76	114	10.6	126	12.9	138	15.3
1700	63450	0.180	81	6.76	92	8.04	103	9.58	114	11.4	126	13.6	136	16.0
1800	67170	0.202	83	7.76	94	8.99	104	10.6	114	12.3	125	14.4	136	16.8
1900	70910	0.225	86	8.78	96	10.1	105	11.7	115	13.4	125	15.4	135	17.7
2000	74640	0.250	88	9.93	98	11.3	107	12.9	116	14.7	125	16.6	135	18.7
2100	78380	0.275	91	11.1	99	12.7	109	14.2	117	15.9	126	17.9	135	20.1
2200	82110	0.302	93	12.4	102	14.1	111	15.7	119	17.3	127	19.3	136	21.6
2300	85840	0.330	96	13.9	104	15.7	113	17.3	121	19.0	128	20.9	136	23.0
2400	89570	0.360	99	15.5	107	17.4	114	19.0	122	20.7	129	22.7	138	24.7
2500	93300	0.390	102	17.1	109	19.0	117	21.1	124	22.6	131	24.5	139	26.6
2600	97040	0.422	105	19.0	112	21.1	119	22.9	126	24.9	133	26.6	140	28.9
2800	104500	0.489	111	23.0	117	25.2	124	27.4	130	29.5	137	31.2	144	33.3
3000	111970	0.560	117	28.2	123	29.7	128	32.5	135	34.6	141	36.6	146	38.7
3200	119430	0.638					134	37.9	140	40.5	146	42.8	152	45.1
3400	126900	0.721									151	49.7	156	52.2

NO. 16 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S. P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1300	48520	0.106	154	16.4										
1400	52250	0.122	152	16.9	173	22.6	193	28.4						
1500	55980	0.141	150	17.5	171	23.0	191	29.4	208	35.6				
1600	59720	0.160	149	18.1	169	23.9	189	30.2	206	36.6	223	43.5		
1700	63450	0.180	147	18.6	168	24.4	187	31.0	204	37.4	221	44.8	252	60.4
1800	67170	0.202	146	19.4	166	25.3	184	31.8	202	38.4	219	45.8	249	61.4
1900	70910	0.225	145	20.3	164	26.1	183	32.5	200	39.4	217	46.9	247	62.5
2000	74640	0.250	144	21.3	164	27.1	182	33.3	198	40.5	214	47.9	244	63.8
2100	78380	0.275	144	22.5	163	28.2	180	34.6	197	41.5	213	49.2	243	65.0
2200	82110	0.302	144	23.8	162	29.2	179	35.6	195	42.5	211	50.2	241	66.3
2300	85840	0.330	144	25.4	161	30.7	178	36.9	194	43.8	210	51.5	238	67.6
2400	89570	0.360	145	27.1	161	32.0	178	38.4	193	45.3	208	52.7	237	69.1
2500	93300	0.390	146	29.2	161	34.1	177	39.9	192	46.6	207	54.3	235	70.7
2600	97040	0.422	147	31.0	162	35.9	176	41.7	191	48.4	206	55.8	234	72.2
2800	104500	0.489	150	35.6	163	40.7	177	46.3	190	52.2	204	59.7	231	75.8
3000	111970	0.560	154	41.0	166	45.8	178	51.5	191	57.4	204	64.0	230	80.1
3200	119430	0.638	157	46.9	169	52.0	180	57.4	192	63.5	204	70.2	228	85.3
3400	126900	0.721	162	54.0	173	58.6	184	64.3	194	70.2	205	76.6	228	91.1
3600	134380	0.810	166	62.0	177	66.6	187	71.9	197	78.3	208	84.2	229	98.8
3800	141810	0.900					191	80.7	200	86.5	209	93.2	230	107.0
4000	149300	1.000							204	96.3	213	102.4	231	116.7

NO. 17 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	42140	0.063	68	3.01	85	4.71								
1100	46350	0.076	68	3.35	84	5.03								
1200	50560	0.090	68	3.82	84	5.41	98	7.46						
1300	54780	0.106	69	4.34	83	5.90	97	7.89	110	10.2				
1400	58980	0.122	71	5.00	84	6.50	97	8.44	109	10.7	121	13.3		
1500	63200	0.141	72	5.75	84	7.28	96	9.05	108	11.3	120	13.8	131	16.7
1600	67430	0.160	74	6.62	85	8.09	97	9.88	108	12.0	119	14.5	130	17.3
1700	71630	0.180	76	7.63	87	9.08	97	10.8	107	12.9	118	15.3	128	18.1
1800	75840	0.202	78	8.76	88	10.2	98	11.9	108	13.9	118	16.2	128	18.9
1900	80050	0.225	81	9.91	90	11.4	99	13.2	108	15.1	118	17.4	127	20.0
2000	84270	0.250	83	11.2	92	12.8	101	14.6	109	16.5	118	18.7	127	21.1
2100	88490	0.275	85	12.6	94	14.4	102	16.1	110	18.0	118	20.2	127	22.7
2200	92690	0.302	88	14.0	96	15.9	104	17.7	112	19.5	120	21.8	128	24.4
2300	96900	0.330	91	15.7	98	17.8	106	19.5	114	21.4	121	23.6	128	26.0
2400	101130	0.360	93	17.5	101	19.6	108	21.5	115	23.4	122	25.6	130	27.9
2500	105340	0.390	96	19.3	103	21.5	110	23.8	117	25.5	124	27.7	131	30.1
2600	109560	0.422	99	21.5	105	23.8	112	25.9	119	28.1	125	30.1	132	32.7
2800	117990	0.489	104	26.0	110	28.5	117	30.9	122	33.2	129	35.3	135	37.6
3000	126410	0.560	110	31.8	116	33.5	121	36.7	127	39.0	133	41.3	138	43.6
3200	134820	0.638					127	42.8	132	45.7	138	48.3	143	50.9
3400	143260	0.721									142	56.1	147	59.0

NO. 17 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S. P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	54780	0.106	145	18.5										
1400	58980	0.122	143	19.1	162	25.5	181	32.1						
1500	63200	0.141	141	19.7	161	26.0	180	33.2	196	40.2				
1600	67430	0.160	140	20.4	160	27.0	178	34.1	194	41.3	210	49.1		
1700	71630	0.180	138	21.0	158	27.6	176	35.0	192	42.2	208	50.6	237	68.2
1800	75840	0.202	137	21.9	156	28.6	174	35.8	190	43.4	206	51.7	235	69.4
1900	80050	0.225	137	22.9	155	29.5	172	36.7	188	44.5	204	52.9	232	70.5
2000	84270	0.250	136	24.1	154	30.6	171	37.6	187	45.7	202	54.1	230	72.0
2100	88490	0.275	136	25.4	153	31.8	170	39.0	185	46.8	200	55.5	229	73.4
2200	92690	0.302	135	26.9	152	33.0	168	40.2	184	48.0	199	56.7	227	74.9
2300	96900	0.330	136	28.7	152	34.7	168	41.6	182	49.4	198	58.1	224	76.3
2400	101130	0.360	137	30.6	152	36.1	167	43.4	181	51.2	195	59.5	223	78.0
2500	105340	0.390	137	33.0	152	38.4	167	45.1	181	52.6	195	61.3	221	79.8
2600	109560	0.432	138	35.0	152	40.5	166	47.1	180	54.6	194	63.0	220	81.5
2800	117990	0.489	141	40.2	154	46.0	167	52.3	179	59.0	192	67.3	218	85.6
3000	126410	0.560	145	46.2	156	51.7	168	58.1	180	64.7	192	72.3	217	90.5
3200	134820	0.638	148	52.9	159	58.7	170	64.7	181	71.7	192	79.2	215	96.2
3400	143260	0.721	152	61.0	162	66.2	173	72.5	182	79.2	193	86.4	214	102.9
3600	151700	0.810	156	69.9	167	75.1	176	81.2	185	88.4	195	95.1	215	111.6
3800	160100	0.900					180	91.0	188	97.7	197	105.2	217	120.8
4000	168550	1.000							192	108.7	200	115.6	218	131.8

NO. 18 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	47240	0.063	65	3.37	81	5.28								
1100	51960	0.076	64	3.76	80	5.64								
1200	56680	0.090	65	4.28	80	6.06	93	8.36						
1300	61420	0.106	66	4.86	78	6.61	92	8.85	104	11.4				
1400	66130	0.122	67	5.61	79	7.29	91	9.46	103	12.0	115	14.9		
1500	70860	0.141	68	6.45	80	8.17	91	10.2	102	12.6	113	15.5	124	18.7
1600	75590	0.160	70	7.42	80	9.07	91	11.1	102	13.5	112	16.3	122	19.4
1700	80300	0.180	72	8.55	82	10.2	92	12.1	101	14.4	112	17.2	121	20.3
1800	85010	0.202	74	9.82	83	11.4	92	13.4	102	15.6	111	18.2	121	21.2
1900	89750	0.225	76	11.1	85	12.8	93	14.8	102	16.9	111	19.5	120	22.4
2000	94480	0.250	78	12.6	87	14.3	95	16.3	103	18.5	111	21.0	120	23.7
2100	99200	0.275	81	14.1	88	16.1	97	18.0	104	20.2	112	22.7	120	25.4
2200	103910	0.302	83	15.7	91	17.9	98	19.8	106	21.9	113	24.4	121	27.3
2300	108650	0.330	86	17.6	93	19.9	100	21.9	107	24.0	114	26.4	121	29.1
2400	113370	0.360	88	19.6	95	22.0	102	24.1	108	26.3	115	28.7	122	31.3
2500	118100	0.390	91	21.7	97	24.1	104	26.6	110	28.6	117	31.2	123	33.7
2600	122820	0.422	93	24.1	100	26.6	106	29.0	112	31.5	118	33.7	125	36.6
2800	132260	0.489	98	29.1	104	31.9	110	34.7	116	37.3	122	39.5	128	42.1
3000	141710	0.560	104	35.7	110	37.6	115	41.2	120	43.8	126	46.3	130	48.9
3200	151160	0.638					120	48.0	125	51.2	130	54.1	135	57.0
3400	160600	0.721									135	62.9	139	66.1

NO. 18 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M	H. P.
1300	61420	0.106	137	20.7										
1400	66130	0.122	135	21.4	153	28.6	171	36.0						
1500	70860	0.141	133	22.1	152	29.2	170	37.3	185	45.0				
1600	75590	0.160	132	22.9	151	30.3	168	38.2	183	46.3	198	55.1		
1700	80300	0.180	131	23.6	149	30.9	166	39.2	181	47.3	196	56.7	224	76.5
1800	85010	0.202	130	24.6	147	32.1	164	40.2	180	48.6	195	58.0	222	77.8
1900	89750	0.225	129	25.6	146	33.1	163	41.2	178	49.9	193	59.3	220	79.1
2000	94480	0.250	128	27.0	146	34.4	162	42.1	176	51.2	191	60.6	217	80.7
2100	99200	0.275	128	28.4	145	35.7	160	43.8	175	52.5	189	62.2	216	82.3
2200	103910	0.302	128	30.2	144	36.9	159	45.0	173	53.8	188	63.5	215	83.9
2300	108650	0.330	128	32.2	143	38.9	158	46.7	172	55.4	187	65.1	212	85.5
2400	113370	0.360	129	34.4	143	40.5	158	48.6	171	57.4	185	66.8	211	87.5
2500	118100	0.390	130	36.9	143	43.1	157	50.6	171	59.0	184	68.7	209	89.4
2600	122820	0.432	131	39.7	144	45.4	157	52.8	170	61.2	183	70.6	208	91.4
2800	132260	0.489	133	45.0	145	51.5	157	58.7	169	66.1	182	75.5	206	95.9
3000	141710	0.560	137	51.8	147	58.0	158	65.1	170	72.6	181	81.0	205	101.4
3200	151160	0.638	140	59.3	150	65.8	160	72.6	171	80.3	182	88.8	203	107.9
3400	160600	0.721	144	68.4	153	74.2	163	81.3	172	88.8	182	96.9	202	115.3
3600	170070	0.810	147	78.4	157	84.2	166	91.0	175	99.2	185	106.6	203	125.1
3800	179500	0.900					170	102.1	178	109.5	186	117.9	205	135.4
4000	188950	1.000							181	121.8	189	129.6	206	147.7

NO. 19 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	52630	0.063	61	3.76	76	5.88								
1100	57900	0.076	61	4.19	75	6.28								
1200	63150	0.090	61	4.77	75	6.75	88	9.31						
1300	68430	0.106	62	5.42	74	7.36	87	9.86	98	12.7				
1400	73680	0.122	63	6.25	75	8.12	86	10.6	97	13.3	109	16.7		
1500	78950	0.141	65	7.18	75	9.10	86	11.3	97	14.1	107	17.3	117	20.8
1600	84220	0.160	66	8.27	76	10.1	86	12.4	96	15.0	106	18.1	116	21.6
1700	89470	0.180	68	9.53	77	11.3	87	13.5	96	16.1	106	19.1	115	22.6
1800	94720	0.202	70	10.9	79	12.7	87	14.9	96	17.4	105	20.3	114	23.7
1900	99990	0.225	72	12.4	81	14.2	89	16.4	97	18.9	105	21.7	114	25.0
2000	105270	0.250	74	14.0	82	16.0	90	18.2	97	20.7	105	23.4	114	26.4
2100	110520	0.275	76	15.7	84	18.0	92	20.1	98	22.5	106	25.3	114	28.3
2200	115780	0.302	79	17.5	86	19.9	93	22.1	100	24.4	107	27.2	114	30.4
2300	121050	0.330	81	19.6	88	22.2	95	24.4	102	26.7	108	29.5	115	32.4
2400	126310	0.360	83	21.8	90	24.5	96	26.8	103	29.2	109	32.0	116	34.8
2500	131580	0.390	86	24.1	92	26.8	99	29.7	104	31.9	111	34.6	117	37.6
2600	136840	0.422	89	26.8	94	29.7	100	32.3	106	35.1	112	37.6	118	40.8
2800	147390	0.489	93	32.5	98	35.6	104	38.6	110	41.5	115	44.1	121	46.9
3000	157890	0.560	99	39.7	104	41.9	109	45.9	114	48.7	119	51.6	123	54.5
3200	168420	0.638					113	53.4	118	57.0	123	60.3	128	63.5
3400	178950	0.721									127	70.0	132	73.6

NO. 19 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1″ S. P.		1¼″ S. P.		1½″ S. P.		1¾″ S. P.		2″ S. P.		2½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	68430	0.106	130	23.1										
1400	73680	0.122	128	23.8	145	31.9	162	40.1						
1500	78950	0.141	126	24.7	144	32.5	161	41.5	175	50.2				
1600	84220	0.160	125	25.5	143	33.7	159	42.6	174	51.6	188	61.4		
1700	89470	0.180	124	26.3	141	34.4	157	43.7	172	52.7	186	63.2	212	85.2
1800	94720	0.202	123	27.4	140	35.7	155	44.8	170	54.2	184	64.6	210	86.6
1900	99990	0.225	122	28.6	139	36.8	154	45.9	169	55.6	183	66.1	208	88.1
2000	105270	0.250	122	30.0	138	38.3	153	46.9	167	57.0	181	67.5	206	89.9
2100	110520	0.275	122	31.7	137	39.7	152	48.7	166	58.5	179	69.3	205	91.7
2200	115780	0.302	121	33.6	136	41.2	151	50.2	164	59.9	178	70.8	203	93.5
2300	121050	0.330	122	35.8	136	43.3	150	52.0	163	61.7	177	72.6	201	95.3
2400	126310	0.360	122	38.3	136	45.1	150	54.2	162	63.9	175	74.4	200	97.5
2500	131580	0.390	123	41.2	136	48.0	149	56.3	162	65.7	174	76.5	198	99.6
2600	136840	0.422	124	43.7	136	50.5	149	58.8	161	68.2	173	78.7	197	101.8
2800	147390	0.489	126	50.2	137	57.4	149	65.3	160	73.6	172	84.1	195	106.9
3000	157890	0.560	130	57.8	140	64.6	150	72.6	161	80.9	172	90.3	194	113.0
3200	168420	0.638	132	66.1	142	73.3	152	80.9	162	89.5	172	98.9	192	120.2
3400	178950	0.721	136	76.2	145	82.7	155	90.6	163	98.9	173	107.9	192	128.5
3600	189490	0.810	140	87.4	149	93.9	157	101.4	166	110.5	175	118.8	193	139.3
3800	199990	0.900					161	113.7	168	122.0	176	131.4	194	150.9
4000	210530	1.000							172	135.7	179	144.4	195	164.6

NO. 20 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	58320	0.063	58	4.16	73	6.52								
1100	64150	0.076	58	4.64	72	6.96								
1200	69980	0.090	58	5.28	72	7.48	84	10.3						
1300	75820	0.106	59	6.00	71	8.16	83	10.9	94	14.1				
1400	81640	0.122	60	6.92	71	9.00	82	11.7	93	14.8	103	18.5		
1500	87480	0.141	62	7.96	72	10.1	82	12.5	92	15.6	102	19.1	112	23.1
1600	93320	0.160	63	9.16	72	11.2	82	13.7	92	16.6	101	20.1	110	23.9
1700	99140	0.180	65	10.6	74	12.6	83	15.0	91	17.8	101	21.2	109	25.1
1800	104960	0.202	67	12.1	75	14.1	83	16.5	92	19.3	100	22.5	109	26.2
1900	110800	0.225	69	13.7	77	15.8	84	18.2	92	20.9	100	24.1	108	27.7
2000	116640	0.250	71	15.5	78	17.7	86	20.2	93	22.9	100	25.9	108	29.3
2100	122480	0.275	73	17.4	80	19.9	87	22.3	94	24.9	101	28.0	108	31.4
2200	128300	0.302	75	19.4	82	22.1	89	24.5	95	27.1	102	30.2	109	33.7
2300	134140	0.330	77	21.8	84	24.6	90	27.1	97	29.6	103	32.7	109	35.9
2400	139960	0.360	79	24.2	86	27.2	92	29.7	98	32.4	104	35.5	110	38.6
2500	145800	0.390	82	26.7	88	29.7	94	32.9	99	35.3	105	38.3	111	41.6
2600	151650	0.422	84	29.7	90	32.9	95	35.8	101	38.9	107	41.6	112	45.2
2800	163300	0.489	89	36.0	94	39.4	99	42.8	104	46.0	110	48.8	115	52.0
3000	174960	0.560	94	44.0	99	46.4	103	50.8	108	54.0	113	57.2	117	60.4
3200	186620	0.638					108	59.2	112	63.2	117	66.8	122	70.4
3400	198300	0.721									121	77.6	125	81.6

NO. 20 NIAGARA CONOIDAL FAN (TYPE N) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

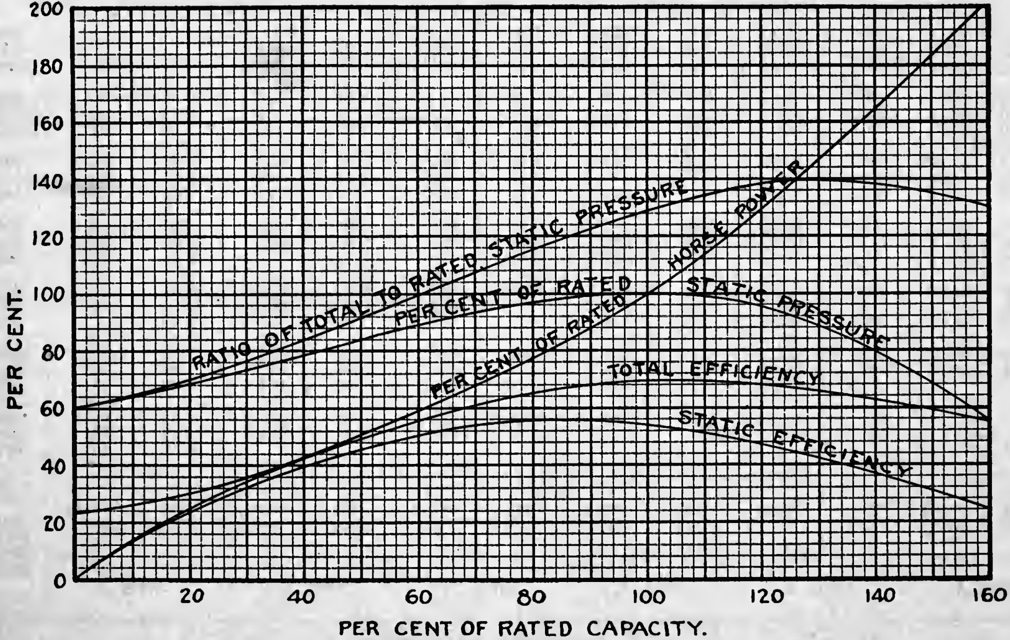
Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1" S. P.		1¼" S. P.		1½" S. P.		1¾" S. P.		2" S. P.		2½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1300	75820	0.106	123	25.6										
1400	81640	0.122	122	26.4	138	35.3	154	44.4						
1500	87480	0.141	120	27.3	137	36.0	153	46.0	167	55.6				
1600	93320	0.160	119	28.2	136	37.4	151	47.2	165	57.2	179	68.0		
1700	99140	0.180	118	29.1	134	38.2	150	48.4	163	58.4	177	70.0	202	94.4
1800	104960	0.202	117	30.4	133	39.5	148	49.6	162	60.0	175	71.6	200	96.0
1900	110800	0.225	116	31.6	132	40.8	147	50.8	160	61.6	174	73.2	198	97.6
2000	116640	0.250	116	33.3	131	42.4	146	52.0	159	63.2	172	74.8	196	99.6
2100	122480	0.275	116	35.1	130	44.0	144	54.0	158	64.8	170	76.8	195	101.6
2200	128300	0.302	115	37.3	130	45.6	143	55.6	156	66.4	169	78.4	193	103.6
2300	134140	0.330	116	39.7	129	48.0	143	57.6	155	68.4	168	80.4	191	105.6
2400	139960	0.360	116	42.4	129	50.0	142	60.0	154	70.8	166	82.4	190	108.0
2500	145800	0.390	117	45.6	129	53.2	142	62.4	154	72.8	166	84.8	188	110.4
2600	151650	0.422	118	48.4	130	56.0	141	65.2	153	75.6	165	87.2	187	112.8
2800	163300	0.489	120	55.6	131	63.6	142	72.4	152	81.6	164	93.2	185	118.4
3000	174960	0.560	123	64.0	133	71.6	143	80.4	153	89.6	163	100.0	184	125.2
3200	186620	0.638	126	73.2	135	81.2	144	89.6	154	99.2	164	109.6	183	133.2
3400	198300	0.721	130	84.4	138	91.6	147	100.4	155	109.6	164	119.6	182	142.4
3600	209960	0.810	133	96.8	142	104.0	150	112.4	158	122.4	166	131.6	183	154.4
3800	221600	0.900					153	126.0	160	135.2	167	145.6	184	167.2
4000	233300	1.000							163	150.4	170	160.0	185	182.4

TOTAL EFFICIENCIES WITH NIAGARA CONOIDAL FANS (TYPE N) FOR VARIOUS OUTLET VELOCITIES AND TOTAL PRESSURES

Outlet Velocity Ft. per Min.	¼″ Static		⅜″ Static		½″ Static		⅝″ Static		¾″ Static		⅞″ Static	
	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.
1000	.313	68.8	.438	61.5	.563	55.2						
1100	.326	70.6	.451	65.2	.576	59.0	.701	54.1				
1200	.340	**70.7**	.465	68.1	.590	63.0	.715	58.1	.840	54.1		
1300	.356	70.6	.481	70.4	.606	66.0	.731	61.9	.856	57.7	.981	52.3
1400	.372	68.7	.497	70.6	.622	68.5	.747	64.7	.872	60.7	.997	57.5
1500	.391	67.2	.516	**70.7**	.641	70.4	.766	67.5	.891	64.0	1.016	58.6
1600	.410	65.6	.535	69.9	.660	**70.7**	.785	69.1	.910	65.4	1.035	63.5
1700	.430	63.3	.555	68.9	.680	**70.7**	.805	70.4	.930	68.1	1.055	65.5
1800	.452	61.4	.577	67.7	.702	70.2	.827	**70.8**	.952	69.7	1.077	67.7
1900	.475	60.2	.600	67.2	.725	69.5	.850	**70.8**	.975	70.5	1.100	69.1
2000	.500	59.0	.625	64.7	.750	68.3	.875	70.0	1.000	**70.6**	1.125	70.3
2100	.525	58.0	.650	62.9	.775	66.9	.900	69.5	1.025	70.5	1.150	70.5
2200	.552	57.2	.677	61.7	.802	66.0	.927	69.0	1.052	70.2	1.177	**70.6**
2300	.580	56.1	.705	60.5	.830	64.8	.955	68.5	1.080	69.6	1.205	**70.6**
2400	.610	55.4	.735	59.5	.860	63.6	.985	66.8	1.110	69.0	1.235	70.3
2500	.640	54.8	.765	59.0	.890	62.0	1.015	65.7	1.140	68.1	1.265	69.4
2600	.672	53.8	.797	57.6	.922	61.2	1.047	64.2	1.172	67.2	1.297	68.4
2800	.739	52.6	.864	56.2	.989	59.3	1.114	62.0	1.239	64.9	1.364	67.0
3000			.935	54.9	1.060	57.2	1.185	60.3	1.310	62.6	1.435	65.1
3200			1.013	54.0	1.138	56.2	1.263	58.6	1.388	60.9	1.513	63.0
3400					1.221	55.0	1.346	57.4	1.471	59.3	1.596	60.9
3600							1.435	56.7	1.560	58.2	1.685	59.8

TOTAL EFFICIENCIES WITH NIAGARA CONOIDAL FANS (TYPE N) FOR VARIOUS OUTLET VELOCITIES AND TOTAL PRESSURES

Outlet Velocity Ft. per Min.	1" Static		1¼" Static		1½" Static		1¾" Static		2" Static		2½" Static	
	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.	Total Press.	Total Eff.
1300	1.106	51.4										
1400	1.122	54.6	1.372	49.8	1.622	46.9						
1500	1.141	57.5	1.391	53.0	1.641	49.2	1.891	46.5				
1600	1.160	60.3	1.410	55.2	1.660	51.2	1.910	48.9	2.160	46.4		
1700	1.180	63.1	1.430	58.0	1.680	54.1	1.930	51.2	2.180	48.5	2.680	44.1
1800	1.202	65.1	1.452	60.4	1.702	56.7	1.952	53.5	2.202	50.6	2.702	46.5
1900	1.225	67.3	1.475	63.1	1.725	58.8	1.975	55.9	2.225	53.0	2.725	48.5
2000	1.250	68.5	1.500	65.0	1.750	61.4	2.000	58.0	2.250	55.1	2.750	50.6
2100	1.275	70.0	1.525	66.8	1.775	63.5	2.025	60.0	2.275	56.8	2.775	52.5
2200	1.302	70.5	1.552	68.3	1.802	65.0	2.052	62.1	2.302	58.9	2.802	54.5
2300	1.330	70.5	1.580	69.5	1.830	66.9	2.080	64.0	2.330	61.0	2.830	56.5
2400	1.360	70.6	1.610	70.5	1.860	68.1	2.110	65.5	2.360	62.9	2.860	58.1
2500	1.390	70.6	1.640	70.6	1.890	69.2	2.140	67.0	2.390	64.5	2.890	59.7
2600	1.422	70.0	1.672	70.8	1.922	70.2	2.172	68.2	2.422	65.9	2.922	61.6
2800	1.489	68.6	1.739	70.2	1.989	70.4	2.239	70.1	2.489	68.4	2.989	64.5
3000	1.560	67.0	1.810	69.5	2.060	70.2	2.310	70.8	2.560	70.1	3.060	67.1
3200	1.638	65.5	1.888	68.0	2.138	69.8	2.388	70.5	2.638	70.7	3.138	69.0
3400	1.721	63.6	1.971	66.8	2.221	68.9	2.471	70.0	2.721	70.6	3.221	70.5
3600	1.810	61.5	2.060	65.0	2.310	67.5	2.560	68.9	2.810	70.2	3.310	70.6
3800			2.150	63.5	2.400	66.0	2.650	68.1	2.900	69.3	3.400	70.6
4000					2.500	65.0	2.750	65.9	3.000	68.4	3.500	70.0



PERFORMANCE CURVE OF BUFFALO NIAGARA CONOIDAL FANS.

Turbo-Conoidal Capacity Tables

For high speed, high efficiency fans suitable for direct connection to motors or turbines, see Turbo-Conoidal capacity tables on pages 278 to 319 inclusive. These fans have speeds for corresponding capacities and pressures which are nearly double those of the Niagara Conoidal of the same size. The dimensions of the housing are identical with those of the Niagara Conoidal. Complete and separate tables of capacities, speeds and horsepowers at various static pressures and outlet velocities are given for each size of single inlet fan as in the Niagara Conoidal tables. This enables the engineer to select a fan for a fixed direct connection speed and for any condition of static pressure and capacity.

It will be noted from the performance curves on page 320 that the pressure builds up rapidly with decreased capacity and increased resistance. In this respect it is in direct contrast with pressure capacity characteristic of the Niagara Conoidal.

For public building work where extreme quietness of operation is essential the following may be taken as conservative conditions of operation of the Turbo-Conoidal fans:—

At 1 in. static pressure, 1600 outlet velocity.
At ¾ in. static pressure, 1800 outlet velocity.
At ½ in. static pressure, 2000 outlet velocity.
At ¼ in. static pressure, 2200 outlet velocity.

For exhausting and for systems blowing through heaters, these velocities may be considerably increased.

For industrial work any desired outlet velocity may be used for static pressure up to 6 or 7 inches.

Double width fans with two inlets give double the capacities and horsepowers given in the tables.

NO. 2½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R. P. M.	H.P.	R. P. M.	H.P.	R. P. M.	H.P.	R. P. M.	H.P.	R. P. M.	H.P.	R. P. M.	H.P.	R. P. M.	H.P.
1000	910	.063	804	.08	908	.10	996	.12	1084	.15	1160	.17	1232	.20	1304	.24
1100	1000	.076	840	.09	944	.12	1032	.14	1112	.17	1188	.20	1256	.22	1324	.25
1200	1090	.090	876	.11	980	.14	1064	.16	1140	.19	1216	.22	1284	.25	1352	.28
1300	1190	.106	916	.13	1016	.16	1096	.19	1176	.22	1248	.25	1316	.28	1380	.31
1400	1280	.122	956	.15	1052	.18	1132	.21	1208	.25	1280	.28	1344	.31	1408	.35
1500	1370	.141	1000	.17	1088	.21	1172	.24	1244	.28	1312	.31	1376	.35	1440	.38
1600	1460	.160	1040	.19	1128	.23	1208	.27	1280	.31	1344	.35	1408	.39	1472	.42
1700	1550	.180	1084	.22	1168	.26	1244	.30	1316	.35	1380	.39	1444	.43	1508	.47
1800	1640	.202	1124	.25	1208	.30	1284	.34	1352	.38	1420	.43	1480	.47	1540	.51
1900	1730	.225	1164	.28	1248	.33	1324	.38	1392	.43	1456	.47	1516	.52	1576	.56
2000	1820	.250	1208	.32	1288	.37	1364	.42	1428	.47	1492	.52	1552	.56	1608	.61
2100	1910	.275	1256	.36	1328	.41	1404	.46	1468	.52	1532	.57	1588	.62	1644	.67
2200	2010	.302	1300	.40	1372	.45	1444	.51	1508	.57	1568	.62	1628	.68	1684	.73
2300	2100	.330	1348	.44	1416	.50	1484	.56	1548	.62	1608	.68	1668	.74	1724	.79
2400	2190	.360	1392	.49	1460	.55	1528	.61	1588	.68	1648	.74	1704	.80	1760	.86
2500	2270	.390	1440	.55	1504	.61	1568	.67	1632	.74	1688	.81	1744	.87	1796	.93
2600	2370	.422	1484	.60	1548	.66	1608	.73	1672	.80	1732	.87	1780	.94	1836	1.00
2700	2460	.455	1532	.67	1596	.73	1652	.80	1712	.87	1772	.94	1820	1.01	1876	1.08
2800	2550	.489	1576	.73	1640	.80	1700	.87	1756	.95	1812	1.02	1860	1.09	1916	1.16
2900	2640	.525	1628	.80	1688	.88	1744	.94	1800	1.02	1852	1.10	1904	1.17	1956	1.25
3000	2730	.560	1676	.87	1732	.95	1788	1.02	1840	1.10	1896	1.18	1948	1.26	1996	1.34

NO. 2½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	1090	.090	1472	.34	1592	.40	1796	.54	1984	.71				
1300	1190	.106	1500	.37	1612	.45	1816	.57	2000	.74				
1400	1280	.122	1528	.41	1636	.48	1840	.62	2020	.78	2188	.97	2344	1.16
1500	1370	.141	1556	.45	1664	.53	1860	.67	2040	.82	2208	1.01	2364	1.22
1600	1460	.160	1588	.50	1692	.58	1884	.73	2064	.88	2232	1.06	2384	1.26
1700	1550	.180	1616	.54	1720	.63	1912	.79	2088	.95	2252	1.12	2404	1.32
1800	1640	.202	1644	.59	1752	.68	1940	.86	2112	1.02	2272	1.20	2424	1.39
1900	1730	.225	1680	.65	1784	.74	1968	.92	2140	1.10	2296	1.28	2444	1.47
2000	1820	.250	1716	.70	1816	.80	2000	.99	2168	1.18	2320	1.37	2464	1.57
2100	1910	.275	1752	.76	1848	.86	2032	1.07	2196	1.27	2344	1.47	2488	1.67
2200	2010	.302	1788	.83	1884	.93	2060	1.14	2224	1.35	2372	1.56	2516	1.77
2300	2100	.330	1824	.90	1916	1.00	2092	1.23	2256	1.44	2400	1.66	2544	1.88
2400	2190	.360	1860	.97	1952	1.08	2124	1.31	2288	1.54	2432	1.77	2572	2.00
2500	2270	.390	1896	1.05	1988	1.16	2160	1.40	2320	1.64	2464	1.88	2600	2.12
2600	2370	.422	1936	1.13	2024	1.25	2196	1.49	2352	1.74	2496	1.99	2632	2.24
2700	2460	.455	1972	1.21	2060	1.34	2232	1.59	2384	1.85	2528	2.11	2664	2.37
2800	2550	.489	2012	1.30	2096	1.43	2268	1.70	2420	1.96	2560	2.23	2696	2.50
2900	2640	.525	2048	1.39	2136	1.53	2300	1.80	2452	2.08	2592	2.36	2728	2.64
3000	2730	.560	2088	1.49	2176	1.64	2336	1.93	2488	2.20	2624	2.48	2756	2.77
3200	2920	.638	2168	1.69	2252	1.86	2412	2.17	2556	2.47	2696	2.77	2824	3.08
3400	3100	.721	2244	1.92	2328	2.09	2488	2.44	2632	2.75	2764	3.08	2888	3.41

NO. 3 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	1310	.063	670	.11	757	.15	830	.18	903	.21	967	.25	1027	.28	1087	.34
1100	1440	.076	700	.13	787	.17	860	.21	927	.24	990	.28	1047	.32	1103	.36
1200	1580	.090	730	.15	817	.20	887	.24	950	.28	1013	.32	1070	.36	1127	.40
1300	1710	.106	764	.18	847	.23	913	.27	980	.31	1040	.36	1097	.40	1150	.45
1400	1840	.122	797	.21	877	.26	943	.31	1007	.35	1067	.40	1120	.45	1173	.50
1500	1970	.141	833	.24	907	.29	977	.35	1037	.40	1093	.45	1147	.50	1200	.55
1600	2100	.160	867	.28	940	.33	1006	.39	1067	.45	1120	.50	1173	.55	1227	.61
1700	2230	.180	903	.31	973	.38	1037	.44	1097	.50	1150	.55	1203	.61	1257	.70
1800	2360	.202	937	.36	1007	.42	1070	.49	1127	.55	1183	.61	1233	.67	1283	.73
1900	2490	.225	970	.40	1040	.47	1103	.54	1160	.61	1213	.68	1263	.74	1313	.80
2000	2630	.250	1007	.45	1073	.53	1137	.60	1190	.68	1243	.75	1293	.81	1340	.88
2100	2760	.275	1047	.51	1107	.59	1170	.67	1223	.75	1277	.82	1323	.89	1370	.96
2200	2890	.302	1083	.57	1143	.65	1203	.74	1257	.82	1307	.90	1357	.98	1403	1.05
2300	3020	.330	1123	.64	1180	.72	1237	.80	1290	.89	1340	.98	1390	1.06	1437	1.14
2400	3150	.360	1160	.71	1217	.79	1273	.88	1323	.98	1373	1.06	1420	1.15	1467	1.23
2500	3280	.390	1200	.78	1253	.87	1307	.97	1360	1.06	1407	1.16	1453	1.25	1497	1.34
2600	3410	.422	1237	.87	1290	.96	1340	1.05	1393	1.16	1443	1.26	1483	1.35	1530	1.44
2700	3540	.455	1277	.96	1330	1.05	1377	1.14	1427	1.25	1477	1.36	1517	1.46	1563	1.55
2800	3670	.489	1313	1.05	1367	1.15	1417	1.25	1463	1.36	1510	1.47	1550	1.57	1597	1.67
2900	3810	.525	1357	1.15	1407	1.26	1453	1.36	1500	1.47	1543	1.58	1587	1.69	1630	1.79
3000	3940	.560	1397	1.26	1443	1.37	1490	1.47	1533	1.59	1580	1.70	1623	1.82	1663	1.93

NO. 3 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	1580	.090	1227	.48	1327	.57	1497	.78	1653	1.02				
1300	1710	.106	1250	.54	1343	.65	1513	.82	1667	1.07				
1400	1840	.122	1273	.59	1363	.69	1533	.89	1683	1.12	1823	1.39	1953	1.67
1500	1970	.141	1297	.65	1387	.76	1550	.96	1700	1.18	1840	1.45	1970	1.75
1600	2100	.160	1323	.72	1410	.83	1570	1.05	1720	1.27	1860	1.52	1987	1.82
1700	2230	.180	1347	.78	1433	.90	1593	1.14	1740	1.36	1877	1.61	2003	1.89
1800	2360	.202	1370	.85	1460	.98	1617	1.23	1760	1.48	1893	1.72	2020	1.99
1900	2490	.225	1400	.93	1487	1.07	1640	1.33	1783	1.59	1913	1.85	2037	2.12
2000	2630	.250	1430	1.01	1513	1.15	1667	1.43	1807	1.70	1933	1.98	2053	2.26
2100	2760	.275	1460	1.10	1540	1.25	1693	1.54	1830	1.82	1953	2.11	2073	2.40
2200	2890	.302	1490	1.19	1570	1.34	1717	1.65	1853	1.95	1977	2.25	2097	2.55
2300	3020	.330	1520	1.29	1597	1.45	1743	1.76	1880	2.07	2000	2.39	2120	2.71
2400	3150	.360	1550	1.39	1627	1.56	1770	1.88	1907	2.21	2027	2.55	2143	2.88
2500	3280	.390	1580	1.51	1657	1.68	1800	2.02	1933	2.36	2053	2.70	2167	3.05
2600	3410	.422	1613	1.62	1687	1.80	1830	2.15	1960	2.50	2080	2.86	2193	3.23
2700	3540	.455	1643	1.74	1717	1.93	1860	2.30	1987	2.66	2107	3.03	2220	3.41
2800	3670	.489	1677	1.87	1747	2.06	1890	2.44	2017	2.82	2133	3.21	2247	3.60
2900	3810	.525	1707	2.01	1780	2.21	1917	2.60	2043	2.99	2160	3.39	2273	3.79
3000	3940	.560	1740	2.14	1813	2.35	1947	2.77	2073	3.17	2187	3.57	2297	3.99
3200	4200	.638	1807	2.43	1877	2.67	2010	3.13	2130	3.55	2247	3.99	2353	4.43
3400	4460	.721	1870	2.77	1940	3.02	2073	3.51	2193	3.96	2303	4.43	2407	4.90

NO. 3½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H. P	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1000	1790	.063	574	.15	649	.20	712	.24	774	.29	829	.34	880	.38	932	.46
1100	1970	.076	600	.18	674	.23	737	.28	794	.33	849	.38	897	.44	946	.49
1200	2140	.090	626	.21	700	.27	760	.32	814	.38	869	.43	917	.49	966	.55
1300	2320	.106	654	.25	726	.31	783	.37	840	.43	892	.49	940	.55	986	.61
1400	2500	.122	683	.29	752	.35	809	.42	863	.48	914	.55	960	.61	1006	.68
1500	2680	.141	714	.33	777	.40	837	.47	889	.54	937	.61	983	.68	1029	.75
1600	2860	.160	743	.38	806	.46	863	.53	914	.61	960	.68	1006	.76	1052	.83
1700	3040	.180	774	.43	834	.51	889	.60	940	.68	986	.75	1032	.83	1077	.91
1800	3220	.202	803	.48	863	.58	917	.67	966	.75	1014	.83	1057	.92	1100	1.00
1900	3390	.225	831	.55	892	.65	946	.74	994	.83	1040	.92	1083	1.01	1126	1.10
2000	3570	.250	863	.62	920	.72	974	.82	1020	.92	1065	1.02	1109	1.11	1149	1.20
2100	3750	.275	897	.69	949	.80	1003	.91	1049	1.01	1094	1.11	1134	1.21	1174	1.31
2200	3930	.302	929	.78	980	.88	1032	1.00	1077	1.11	1120	1.22	1163	1.33	1203	1.43
2300	4110	.330	963	.87	1012	.98	1060	1.10	1106	1.22	1149	1.33	1192	1.44	1232	1.55
2400	4290	.360	994	.96	1043	1.08	1092	1.20	1134	1.33	1177	1.45	1217	1.57	1257	1.68
2500	4470	.390	1029	1.07	1074	1.19	1120	1.31	1166	1.45	1206	1.58	1246	1.70	1283	1.82
2600	4650	.422	1060	1.18	1106	1.30	1149	1.43	1194	1.57	1237	1.71	1272	1.83	1312	1.96
2700	4820	.455	1094	1.31	1140	1.43	1180	1.56	1223	1.71	1266	1.85	1300	1.98	1340	2.12
2800	5000	.489	1126	1.43	1172	1.57	1214	1.70	1254	1.85	1294	2.00	1329	2.13	1369	2.28
2900	5180	.525	1163	1.56	1206	1.71	1246	1.84	1286	2.00	1323	2.16	1360	2.30	1397	2.44
3000	5360	.560	1197	1.71	1237	1.87	1277	2.00	1314	2.16	1354	2.31	1392	2.47	1426	2.62

NO. 3½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	2140	.090	1052	.66	1137	.78	1283	1.07	1417	1.39				
1300	2320	.106	1072	.73	1152	.88	1297	1.12	1429	1.45				
1400	2500	.122	1092	.81	1169	.94	1314	1.21	1443	1.53	1563	1.90	1674	2.28
1500	2680	.141	1112	.89	1189	1.03	1329	1.31	1457	1.61	1577	1.98	1689	2.38
1600	2860	.160	1134	.98	1209	1.13	1346	1.43	1474	1.73	1594	2.07	1703	2.48
1700	3040	.180	1154	1.07	1229	1.23	1366	1.55	1492	1.86	1609	2.20	1717	2.58
1800	3220	.202	1174	1.16	1252	1.33	1386	1.68	1509	2.01	1623	2.34	1732	2.71
1900	3390	.225	1200	1.27	1274	1.45	1406	1.81	1529	2.16	1640	2.52	1746	2.88
2000	3570	.250	1226	1.38	1297	1.57	1429	1.94	1549	2.31	1657	2.69	1760	3.07
2100	3750	.275	1252	1.50	1320	1.70	1452	2.09	1569	2.48	1674	2.88	1777	3.27
2200	3930	.302	1277	1.62	1346	1.83	1472	2.24	1589	2.65	1695	3.07	1797	3.47
2300	4110	.330	1303	1.76	1369	1.97	1494	2.40	1612	2.82	1714	3.26	1817	3.69
2400	4290	.360	1329	1.89	1394	2.12	1517	2.57	1634	3.01	1737	3.47	1837	3.92
2500	4470	.390	1355	2.05	1420	2.28	1543	2.74	1657	3.21	1760	3.68	1857	4.15
2600	4650	.422	1383	2.21	1446	2.45	1569	2.93	1680	3.41	1783	3.90	1880	4.39
2700	4820	.455	1409	2.37	1472	2.62	1595	3.12	1703	3.62	1806	4.13	1903	4.64
2800	5000	.489	1437	2.55	1497	2.81	1620	3.32	1729	3.84	1829	4.37	1926	4.90
2900	5180	.525	1463	2.73	1526	3.00	1643	3.54	1752	4.07	1852	4.62	1949	5.16
3000	5360	.560	1492	2.92	1555	3.20	1669	3.77	1777	4.31	1874	4.86	1969	5.43
3200	5720	.638	1549	3.31	1609	3.64	1723	4.26	1826	4.84	1926	5.43	2017	6.03
3400	6070	.721	1603	3.77	1663	4.10	1777	4.77	1880	5.39	1975	6.03	2063	6.68

NO. 4 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	2330	.063	503	.20	568	.26	623	.32	678	.38	725	.44	770	.50	815	.60
1100	2570	.076	525	.23	590	.30	645	.37	695	.43	743	.50	785	.57	828	.63
1200	2800	.090	548	.27	613	.35	665	.42	713	.49	760	.57	803	.64	845	.71
1300	3030	.106	573	.32	635	.40	685	.48	735	.56	780	.64	823	.72	863	.80
1400	3270	.122	598	.37	658	.46	708	.55	755	.63	800	.71	840	.80	880	.88
1500	3500	.141	625	.43	680	.52	733	.62	778	.71	820	.80	860	.89	900	.98
1600	3760	.160	650	.49	705	.59	755	.69	800	.79	840	.89	880	.99	920	1.08
1700	3970	.180	678	.56	730	.67	778	.78	822	.88	863	.98	903	1.09	943	1.19
1800	4200	.202	703	.63	755	.75	802	.87	845	.98	888	1.09	925	1.20	963	1.31
1900	4430	.225	728	.71	780	.84	828	.97	870	1.09	910	1.20	948	1.32	985	1.43
2000	4670	.250	755	.81	805	.94	853	1.07	893	1.20	932	1.33	970	1.44	1005	1.56
2100	4900	.275	785	.91	830	1.04	878	1.19	918	1.32	958	1.46	993	1.59	1028	1.71
2200	5130	.302	813	1.01	858	1.15	903	1.31	943	1.45	980	1.59	1018	1.74	1053	1.86
2300	5370	.330	843	1.13	885	1.28	928	1.43	968	1.59	1005	1.74	1043	1.88	1078	2.02
2400	5660	.360	870	1.26	912	1.41	955	1.57	993	1.74	1030	1.89	1065	2.05	1100	2.19
2500	5830	.390	900	1.39	940	1.55	980	1.71	1020	1.89	1055	2.06	1090	2.22	1123	2.37
2600	6070	.422	928	1.55	968	1.70	1005	1.87	1045	2.05	1083	2.23	1113	2.40	1148	2.56
2700	6300	.455	958	1.71	998	1.87	1032	2.03	1070	2.23	1108	2.42	1138	2.59	1173	2.76
2800	6530	.489	985	1.87	1025	2.05	1062	2.23	1098	2.42	1133	2.61	1163	2.79	1198	2.97
2900	6770	.525	1018	2.04	1055	2.24	1090	2.41	1125	2.61	1158	2.82	1190	3.00	1223	3.19
3000	7000	.560	1048	2.23	1082	2.44	1118	2.61	1150	2.82	1185	3.01	1218	3.22	1248	3.43

NO. 4 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	2800	.090	920	.86	995	1.01	1123	1.39	1240	1.81				
1300	3030	.106	938	.95	1008	1.15	1135	1.47	1250	1.90				
1400	3270	.122	955	1.05	1023	1.23	1150	1.58	1263	1.99	1368	2.47	1465	2.98
1500	3500	.141	973	1.16	1040	1.35	1163	1.71	1275	2.11	1380	2.58	1478	3.11
1600	3730	.160	993	1.27	1058	1.47	1178	1.86	1290	2.26	1395	2.71	1490	3.23
1700	3970	.180	1010	1.39	1075	1.61	1195	2.02	1305	2.43	1408	2.87	1503	3.37
1800	4200	.202	1028	1.52	1095	1.74	1213	2.19	1320	2.62	1420	3.06	1515	3.55
1900	4430	.225	1050	1.65	1115	1.89	1230	2.36	1338	2.82	1435	3.29	1528	3.76
2000	4670	.250	1073	1.80	1135	2.05	1250	2.54	1355	3.02	1450	3.51	1540	4.01
2100	4900	.275	1095	1.96	1155	2.21	1270	2.73	1373	3.24	1465	3.76	1555	4.27
2200	5130	.302	1118	2.12	1178	2.39	1288	2.93	1390	3.46	1483	4.00	1573	4.54
2300	5370	.330	1140	2.29	1198	2.57	1308	3.14	1410	3.69	1500	4.26	1590	4.82
2400	5660	.360	1163	2.47	1220	2.77	1328	3.35	1430	3.94	1520	4.53	1608	5.12
2500	5830	.390	1185	2.68	1243	2.98	1350	3.58	1450	4.19	1540	4.80	1625	5.43
2600	6070	.422	1210	2.88	1265	3.19	1373	3.83	1470	4.45	1560	5.09	1645	5.74
2700	6300	.455	1233	3.10	1288	3.42	1395	4.08	1490	4.73	1580	5.39	1665	6.06
2800	6530	.489	1258	3.33	1310	3.67	1418	4.34	1513	5.02	1600	5.71	1685	6.40
2900	6770	.525	1280	3.56	1335	3.92	1438	4.62	1533	5.31	1620	6.03	1705	6.75
3000	7000	.560	1305	3.81	1360	4.19	1460	4.93	1555	5.63	1640	6.35	1725	7.10
3200	7460	.638	1355	4.32	1408	4.75	1508	5.56	1598	6.32	1685	7.09	1765	7.87
3400	7930	.721	1403	4.92	1455	5.36	1555	6.23	1645	7.04	1728	7.87	1805	8.72

NO. 4½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	2950	.063	447	.25	505	.33	553	.40	602	.48	645	.56	685	.63	725	.76
1100	3250	.076	467	.29	525	.38	573	.46	618	.55	660	.63	698	.72	736	.80
1200	3540	.090	487	.35	545	.44	591	.53	633	.63	676	.72	713	.81	751	.90
1300	3840	.106	509	.41	565	.51	609	.60	653	.71	693	.81	731	.90	767	1.01
1400	4130	.122	531	.47	585	.58	629	.69	671	.79	711	.90	747	1.01	782	1.12
1500	4430	.141	556	.54	605	.66	651	.78	691	.89	729	1.01	765	1.12	800	1.24
1600	4720	.160	578	.62	627	.75	671	.88	711	1.00	747	1.12	782	1.25	818	1.37
1700	5020	.180	602	.70	649	.85	691	.98	731	1.12	767	1.25	802	1.38	838	1.51
1800	5310	.202	625	.80	671	.96	713	1.10	751	1.24	789	1.38	822	1.52	856	1.65
1900	5610	.225	647	.90	693	1.07	736	1.22	773	1.38	809	1.52	842	1.67	876	1.81
2000	5910	.250	671	1.02	716	1.19	758	1.36	793	1.52	829	1.68	862	1.83	893	1.98
2100	6200	.275	698	1.15	738	1.32	780	1.50	816	1.68	851	1.84	882	2.01	913	2.16
2200	6500	.302	722	1.28	762	1.46	802	1.65	838	1.83	871	2.02	904	2.20	936	2.36
2300	6790	.330	749	1.43	787	1.62	825	1.81	860	2.01	893	2.20	927	2.38	958	2.56
2400	7090	.360	773	1.59	811	1.78	849	1.99	882	2.20	916	2.39	947	2.59	978	2.78
2500	7380	.390	800	1.76	836	1.97	871	2.18	907	2.39	938	2.60	969	2.81	998	3.00
2600	7680	.422	825	1.96	860	2.15	893	2.37	929	2.60	962	2.83	989	3.03	1020	3.24
2700	7970	.455	851	2.16	887	2.36	918	2.57	951	2.82	985	3.06	1011	3.28	1042	3.50
2800	8270	.489	876	2.37	911	2.59	945	2.82	976	3.06	1007	3.30	1033	3.53	1064	3.76
2900	8560	.525	905	2.58	938	2.83	969	3.05	1000	3.31	1029	3.56	1058	3.79	1087	4.01
3000	8860	.560	931	2.83	962	3.09	993	3.30	1022	3.56	1053	3.82	1082	4.08	1109	4.33

NO. 4½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H.P.
1200	3540	.090	818	1.08	884	1.28	998	1.76	1102	2.29				
1300	3840	.106	833	1.20	896	1.45	1009	1.86	1111	2.40				
1400	4130	.122	849	1.33	909	1.55	1022	2.00	1122	2.52	1216	3.13	1302	3.77
1500	4430	.141	864	1.47	924	1.71	1033	2.17	1133	2.66	1227	3.26	1313	3.94
1600	4720	.160	882	1.61	940	1.86	1047	2.36	1147	2.86	1240	3.42	1323	4.09
1700	5020	.180	898	1.76	956	2.03	1062	2.56	1160	3.07	1251	3.63	1336	4.26
1800	5310	.202	913	1.92	973	2.20	1078	2.77	1173	3.32	1262	3.87	1347	4.49
1900	5610	.225	933	2.09	991	2.40	1093	2.98	1189	3.57	1274	4.16	1358	4.76
2000	5910	.250	953	2.28	1009	2.59	1111	3.21	1205	3.82	1289	4.45	1369	5.07
2100	6200	.275	973	2.47	1027	2.80	1129	3.45	1220	4.10	1302	4.75	1382	5.41
2200	6500	.302	993	2.68	1047	3.02	1144	3.70	1236	4.38	1318	5.07	1398	5.74
2300	6790	.330	1013	2.90	1065	3.25	1162	3.97	1253	4.66	1333	5.39	1413	6.10
2400	7090	.360	1033	3.13	1085	3.50	1180	4.24	1271	4.98	1351	5.73	1429	6.48
2500	7380	.390	1053	3.39	1105	3.77	1200	4.53	1289	5.31	1369	6.07	1445	6.87
2600	7680	.422	1076	3.65	1125	4.04	1220	4.84	1308	5.63	1387	6.44	1462	7.26
2700	7970	.455	1096	3.92	1144	4.33	1240	5.16	1325	5.98	1404	6.83	1480	7.67
2800	8270	.489	1118	4.21	1165	4.64	1260	5.49	1345	6.35	1422	7.23	1498	8.10
2900	8560	.525	1138	4.51	1187	4.96	1278	5.84	1362	6.72	1440	7.64	1516	8.54
3000	8860	.560	1160	4.82	1209	5.30	1298	6.24	1382	7.13	1458	8.04	1531	8.98
3200	9450	.638	1205	5.47	1251	6.01	1340	7.04	1420	8.00	1498	8.97	1569	9.96
3400	10040	.721	1247	6.23	1293	6.78	1382	7.89	1462	8.91	1536	9.96	1605	11.0

NO. 5 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1000	3650	.063	402	.31	454	.40	498	.50	542	.59	580	.69	616	.78	652	.94
1100	4010	.076	420	.36	472	.47	516	.57	556	.68	594	.78	628	.89	662	.99
1200	4380	.090	438	.43	490	.54	532	.66	570	.77	608	.89	642	1.00	676	1.11
1300	4740	.106	458	.50	508	.63	548	.75	588	.87	624	1.00	658	1.12	690	1.24
1400	5100	.122	478	.58	526	.72	566	.85	604	.98	640	1.11	672	1.25	704	1.38
1500	5470	.141	500	.67	544	.82	586	.96	622	1.10	656	1.24	688	1.39	720	1.53
1600	5830	.160	520	.77	564	.93	604	1.08	640	1.24	672	1.38	704	1.54	736	1.69
1700	6200	.180	542	.87	584	1.05	622	1.21	658	1.38	690	1.54	722	1.70	754	1.86
1800	6560	.202	562	.99	604	1.18	642	1.36	676	1.53	710	1.70	740	1.87	770	2.04
1900	6930	.225	582	1.12	624	1.32	662	1.51	696	1.70	728	1.88	758	2.06	788	2.24
2000	7290	.250	604	1.26	644	1.47	682	1.68	714	1.88	746	2.08	776	2.26	804	2.44
2100	7660	.275	628	1.42	664	1.63	702	1.85	734	2.07	766	2.27	794	2.48	822	2.67
2200	8020	.302	650	1.58	686	1.80	722	2.04	754	2.26	784	2.49	814	2.71	842	2.91
2300	8380	.330	674	1.77	708	2.00	742	2.23	774	2.48	804	2.72	834	2.94	862	3.16
2400	8750	.360	696	1.96	730	2.20	764	2.45	794	2.71	824	2.95	852	3.20	880	3.43
2500	9110	.390	720	2.18	752	2.43	784	2.68	816	2.95	844	3.22	872	3.47	898	3.71
2600	9480	.422	742	2.41	774	2.66	804	2.93	836	3.21	866	3.49	890	3.74	918	4.00
2700	9840	.455	766	2.66	798	2.91	826	3.18	856	3.48	886	3.78	910	4.05	938	4.32
2800	10200	.489	788	2.93	820	3.20	850	3.48	878	3.79	906	4.08	930	4.36	958	4.65
2900	10570	.525	814	3.19	844	3.50	872	3.76	900	4.08	926	4.40	952	4.68	978	4.98
3000	10940	.560	838	3.49	866	3.81	894	4.08	920	4.40	948	4.72	974	5.04	998	5.35

NO. 5 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼″ S. P.		1½″ S. P.		2″ S. P.		2½″ S. P.		3″ S. P.		3½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	4380	.090	736	1.34	796	1.58	898	2.18	992	2.83				
1300	4740	.106	750	1.49	806	1.79	908	2.29	1000	2.97				
1400	5100	.122	764	1.65	818	1.91	920	2.47	1010	3.11	1094	3.87	1172	4.65
1500	5470	.141	778	1.81	832	2.11	930	2.68	1020	3.29	1104	4.03	1182	4.87
1600	5830	.160	794	1.99	846	2.30	942	2.91	1032	3.53	1116	4.23	1192	5.05
1700	6200	.180	808	2.18	860	2.51	956	3.16	1044	3.79	1126	4.48	1202	5.26
1800	6560	.202	822	2.37	876	2.72	970	3.42	1056	4.10	1136	4.78	1212	5.54
1900	6930	.225	840	2.58	892	2.96	984	3.68	1070	4.41	1148	5.14	1222	5.88
2000	7290	.250	858	2.81	908	3.20	1000	3.96	1084	4.72	1160	5.49	1232	6.26
2100	7660	.275	876	3.06	924	3.46	1016	4.26	1098	5.06	1172	5.87	1244	6.68
2200	8020	.302	894	3.31	942	3.73	1030	4.57	1112	5.41	1186	6.26	1258	7.09
2300	8380	.330	912	3.58	958	4.01	1046	4.90	1128	5.76	1200	6.65	1272	7.53
2400	8750	.360	930	3.87	976	4.33	1062	5.23	1144	6.15	1216	7.08	1286	8.00
2500	9110	.390	948	4.19	994	4.65	1080	5.60	1160	6.55	1232	7.50	1300	8.48
2600	9480	.422	968	4.50	1012	4.99	1098	5.98	1176	6.96	1248	7.95	1316	8.96
2700	9840	.455	986	4.84	1030	5.35	1116	6.38	1192	7.39	1264	8.43	1332	9.46
2800	10200	.489	1006	5.20	1048	5.73	1134	6.78	1210	7.84	1280	8.93	1348	10.0
2900	10570	.525	1024	5.57	1068	6.12	1150	7.21	1226	8.30	1296	9.43	1364	10.5
3000	10940	.560	1044	5.95	1088	6.54	1168	7.70	1244	8.80	1312	9.93	1378	11.1
3200	11660	.638	1084	6.76	1126	7.43	1206	8.69	1278	9.87	1348	11.1	1412	12.3
3400	12390	.721	1122	7.69	1164	8.38	1244	9.74	1316	11.0	1382	12.3	1444	13.6

NO. 5½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	4410	.063	366	.37	413	.49	453	.60	493	.71	527	.83	560	.95	593	1.14
1100	4850	.076	382	.44	429	.56	469	.69	506	.82	540	.95	571	1.08	602	1.20
1200	5290	.090	398	.52	446	.65	484	.79	518	.93	553	1.07	584	1.21	615	1.35
1300	5730	.106	416	.61	462	.76	498	.90	535	1.05	567	1.20	598	1.36	627	1.50
1400	6170	.122	435	.70	478	.87	515	1.03	549	1.19	582	1.35	611	1.51	640	1.67
1500	6620	.141	455	.81	495	.99	533	1.16	566	1.34	596	1.50	626	1.68	655	1.85
1600	7060	.160	473	.93	513	1.12	549	1.31	582	1.50	611	1.67	640	1.86	669	2.05
1700	7500	.180	493	1.05	531	1.27	566	1.47	598	1.67	627	1.86	656	2.05	686	2.25
1800	7940	.202	511	1.19	549	1.43	584	1.64	615	1.86	646	2.06	673	2.26	700	2.47
1900	8380	.225	529	1.35	567	1.59	602	1.83	633	2.05	662	2.28	689	2.49	716	2.71
2000	8820	.250	549	1.53	585	1.78	620	2.03	649	2.27	678	2.51	706	2.73	731	2.95
2100	9260	.275	571	1.71	604	1.97	638	2.24	667	2.50	696	2.75	722	3.00	747	3.23
2200	9700	.302	591	1.91	624	2.18	656	2.47	686	2.74	713	3.01	740	3.28	766	3.52
2300	10140	.330	613	2.14	644	2.42	675	2.70	704	3.00	731	3.29	758	3.56	784	3.82
2400	10590	.360	633	2.37	664	2.66	695	2.97	722	3.28	749	3.57	775	3.87	800	4.14
2500	11030	.390	655	2.64	684	2.94	713	3.24	742	3.57	767	3.89	793	4.20	816	4.49
2600	11470	.422	675	2.92	704	3.21	731	3.54	760	3.88	787	4.22	809	4.53	835	4.84
2700	11910	.455	697	3.22	726	3.53	751	3.85	778	4.21	806	4.57	827	4.90	853	5.22
2800	12350	.489	716	3.54	745	3.87	773	4.21	798	4.58	824	4.93	846	5.27	871	5.62
2900	12790	.525	740	3.86	767	4.23	793	4.55	818	4.94	842	5.32	866	5.67	889	6.02
3000	13230	.560	762	4.22	787	4.61	813	4.93	836	5.32	862	5.71	886	6.10	907	6.47

NO. 5½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	5290	.090	669	1.62	724	1.91	816	2.63	902	3.42				
1300	5730	.106	682	1.80	733	2.17	826	2.77	909	3.59				
1400	6170	.122	695	1.99	744	2.31	836	2.99	918	3.77	995	4.68	1066	5.63
1500	6620	.141	707	2.19	756	2.55	846	3.24	927	3.98	1004	4.88	1075	5.89
1600	7060	.160	722	2.41	769	2.78	856	3.52	938	4.27	1015	5.11	1083	6.11
1700	7500	.180	735	2.63	782	3.03	869	3.82	949	4.58	1024	5.43	1093	6.36
1800	7940	.202	747	2.87	796	3.29	882	4.14	960	4.96	1034	5.78	1102	6.70
1900	8380	.225	764	3.13	811	3.58	895	4.46	973	5.33	1044	6.21	1111	7.11
2000	8820	.250	780	3.40	826	3.87	909	4.80	986	5.71	1055	6.64	1120	7.58
2100	9260	.275	796	3.70	840	4.18	924	5.16	998	6.12	1066	7.10	1131	8.08
2200	9700	.302	813	4.01	856	4.51	936	5.53	1011	6.54	1078	7.57	1144	8.58
2300	10140	.330	829	4.33	871	4.86	951	5.93	1026	6.97	1091	8.05	1156	9.11
2400	10590	.360	846	4.68	887	5.23	966	6.33	1040	7.44	1106	8.56	1169	9.68
2500	11030	.390	862	5.07	904	5.63	982	6.77	1055	7.93	1120	9.08	1182	10.3
2600	11470	.422	880	5.45	920	6.04	998	7.23	1069	8.42	1135	9.62	1197	10.9
2700	11910	.455	896	5.85	936	6.47	1015	7.72	1084	8.94	1149	10.2	1211	11.5
2800	12350	.489	915	6.29	953	6.93	1031	8.20	1100	9.48	1164	10.8	1226	12.1
2900	12790	.525	931	6.74	971	7.41	1045	8.73	1115	10.1	1178	11.4	1240	12.8
3000	13230	.560	949	7.20	989	7.91	1062	9.32	1131	10.7	1193	12.0	1253	13.4
3200	14110	.638	986	8.17	1024	8.99	1097	10.5	1162	12.0	1226	13.4	1284	14.9
3400	15000	.721	1020	9.29	1058	10.1	1131	11.8	1196	13.3	1257	14.9	1313	16.5

NO. 6 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	5250	.063	335	0.44	378	.58	415	.71	452	.85	483	.99	513	1.13		
1100	5770	.076	350	0.52	393	.67	430	.82	463	.98	495	1.13	523	1.28		
1200	6300	.090	365	0.62	408	.78	443	.94	475	1.11	507	1.28	535	1.44	563	1.60
1300	6820	.106	382	0.72	423	.90	457	1.07	490	1.25	520	1.43	548	1.61	575	1.79
1400	7350	.122	398	0.84	438	1.03	472	1.23	503	1.41	533	1.60	560	1.80	587	1.99
1500	7870	.141	417	0.96	453	1.18	488	1.38	518	1.59	547	1.79	573	2.00	600	2.20
1600	8400	.160	433	1.10	470	1.34	503	1.56	533	1.78	560	1.99	587	2.22	613	2.43
1700	8920	.180	452	1.25	487	1.51	518	1.75	548	1.98	575	2.22	602	2.45	628	2.68
1800	9450	.202	468	1.42	503	1.70	535	1.96	563	2.21	592	2.45	617	2.69	642	2.93
1900	9970	.225	485	1.61	520	1.89	552	2.17	580	2.45	607	2.71	632	2.97	657	3.22
2000	10500	.250	503	1.82	537	2.12	562	2.41	595	2.70	622	2.99	647	3.25	670	3.51
2100	11020	.275	523	2.04	553	2.34	585	2.67	612	2.98	638	3.27	662	3.57	685	3.84
2200	11550	.302	542	2.28	572	2.59	602	2.94	628	3.26	653	3.58	678	3.90	702	4.19
2300	12070	.330	562	2.55	590	2.87	618	3.22	645	3.58	670	6.91	695	4.23	718	4.55
2400	12600	.360	580	2.82	608	3.17	637	3.53	662	3.91	687	4.25	710	4.61	733	4.93
2500	13120	.390	600	3.14	627	3.50	653	3.85	680	4.25	703	4.63	727	5.00	748	5.34
2600	13650	.422	618	3.47	645	3.82	670	4.21	697	4.62	722	5.03	742	5.39	765	5.76
2700	14170	.455	638	3.83	665	4.20	688	4.58	713	5.01	738	5.44	758	5.83	782	6.21
2800	14700	.489	657	4.21	683	4.61	708	5.01	732	5.45	755	5.87	775	6.27	798	6.69
2900	15220	.525	678	4.59	703	5.04	727	5.42	750	5.88	772	6.34	793	6.74	815	7.17
3000	15750	.560	698	5.02	722	5.49	745	5.87	767	6.34	790	6.80	812	7.25	832	7.71

NO. 6 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	6300	.090	613	1.93	663	2.29	748	3.13	827	4.07				
1300	6820	.106	625	2.14	672	2.58	757	3.30	833	4.27				
1400	7350	.122	637	2.37	682	2.76	767	3.56	842	4.48	910	5.57	977	6.70
1500	7870	.141	648	2.61	693	3.03	775	3.85	850	4.74	920	5.80	985	7.01
1600	8400	.160	662	2.87	705	3.31	785	4.19	860	5.08	930	6.09	993	7.27
1700	8920	.180	673	3.13	717	3.61	797	4.55	870	5.46	938	6.46	1002	7.57
1800	9450	.202	685	3.42	730	3.92	808	4.93	880	5.90	947	6.88	1010	7.98
1900	9970	.225	700	3.72	743	4.26	820	5.30	892	6.34	957	7.39	1018	8.46
2000	10500	.250	715	4.05	757	4.61	833	5.71	903	6.80	967	7.91	1027	9.02
2100	11020	.275	730	4.40	770	4.98	847	6.14	915	7.28	977	8.45	1037	9.61
2200	11550	.302	745	4.77	785	5.37	858	6.58	927	7.78	988	9.01	1048	10.21
2300	12070	.330	760	5.16	798	5.78	872	7.06	940	8.29	1000	9.58	1060	10.84
2400	12600	.360	775	5.57	813	6.23	885	7.54	953	8.86	1013	10.19	1072	11.52
2500	13120	.390	790	6.03	828	6.70	900	8.06	967	9.43	1027	10.80	1083	12.20
2600	13650	.422	807	6.48	843	7.18	915	8.61	980	10.02	1040	11.45	1097	12.91
2700	14170	.455	822	6.96	858	7.70	930	9.18	993	10.64	1053	12.13	1110	13.63
2800	14700	.489	838	7.49	873	8.24	945	9.76	1008	11.29	1067	12.85	1123	14.40
2900	15220	.525	853	8.02	890	8.82	958	10.39	1022	11.95	1080	13.57	1137	15.17
3000	15750	.560	870	8.57	907	9.42	973	11.09	1037	12.67	1093	14.29	1148	15.97
3200	16790	.638	903	9.73	938	10.69	1005	12.51	1065	14.21	1123	15.95	1177	17.71
3400	17850	.721	935	11.06	970	12.06	1037	14.02	1097	15.84	1152	17.71	1203	19.62

NO. 6½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	6160	.063	309	.52	349	.68	383	.84	417	1.00	446	1.16	474	1.32	502	1.59
1100	6780	.076	323	.61	363	.79	397	.96	428	1.15	457	1.32	483	1.51	509	1.67
1200	7390	.090	337	.72	377	.91	409	1.11	439	1.30	468	1.50	494	1.70	520	1.88
1300	8010	.106	352	.85	391	1.06	422	1.26	452	1.47	480	1.68	506	1.89	531	2.10
1400	8620	.122	368	.98	405	1.21	436	1.44	465	1.66	492	1.88	517	2.11	542	2.33
1500	9240	.141	385	1.13	419	1.38	451	1.62	479	1.86	505	2.10	529	2.35	554	2.59
1600	9860	.160	400	1.29	434	1.57	465	1.83	492	2.09	517	2.34	542	2.60	566	2.86
1700	10470	.180	417	1.47	449	1.77	479	2.05	506	2.33	531	2.60	556	2.87	580	3.14
1800	11090	.202	432	1.67	465	1.99	494	2.30	520	2.59	546	2.87	569	3.16	592	3.44
1900	11700	.225	448	1.89	480	2.22	509	2.55	535	2.87	560	3.18	583	3.48	606	3.78
2000	12320	.250	465	2.13	495	2.49	525	2.83	549	3.17	574	3.51	597	3.81	619	4.12
2100	12940	.275	483	2.39	511	2.75	540	3.13	565	3.50	589	3.84	611	4.18	632	4.50
2200	13550	.302	500	2.67	528	3.04	555	3.45	580	3.82	603	4.20	626	4.58	648	4.91
2300	14170	.330	519	2.99	545	3.37	571	3.77	595	4.20	619	4.59	642	4.97	663	5.34
2400	14780	.360	536	3.31	562	3.72	588	4.14	611	4.58	634	4.99	655	5.40	677	5.79
2500	15400	.390	554	3.68	579	4.10	603	4.52	628	4.99	649	5.44	671	5.87	691	6.27
2600	16020	.422	571	4.08	595	4.49	619	4.94	643	5.42	666	5.90	685	6.32	706	6.76
2700	16630	.455	589	4.50	614	4.92	635	5.37	659	5.88	682	6.38	700	6.84	722	7.29
2800	17250	.489	606	4.94	631	5.41	654	5.87	676	6.39	697	6.89	715	7.36	737	7.85
2900	17860	.525	626	5.39	649	5.91	671	6.36	692	6.90	712	7.44	732	7.91	752	8.41
3000	18480	.560	645	5.89	666	6.44	688	6.89	708	7.44	729	7.98	749	8.51	768	9.04

NO. 6½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H.P.
1200	7390	.090	566	2.26	613	2.67	691	3.68	763	4.78				
1300	8010	.106	577	2.51	620	3.03	699	3.87	769	5.01				
1400	8620	.122	588	2.78	629	3.23	708	4.18	777	5.26	842	6.53	902	7.86
1500	9240	.141	599	3.06	640	3.56	716	4.52	785	5.56	849	6.81	909	8.22
1600	9860	.160	611	3.36	651	3.89	725	4.91	794	5.96	859	7.14	917	8.54
1700	10470	.180	622	3.68	661	4.24	735	5.34	803	6.40	866	7.58	925	8.88
1800	11090	.202	632	4.01	674	4.60	746	5.78	812	6.92	874	8.08	932	9.36
1900	11700	.225	646	4.37	686	5.00	757	6.22	823	7.45	883	8.68	940	9.93
2000	12320	.250	660	4.75	699	5.41	769	6.70	834	7.98	892	9.28	948	10.6
2100	12940	.275	674	5.16	711	5.84	782	7.20	845	8.55	902	9.92	957	11.3
2200	13550	.302	688	5.59	725	6.30	792	7.72	856	9.13	912	10.6	968	12.0
2300	14170	.330	702	6.05	737	6.79	805	8.23	868	9.73	923	11.2	979	12.7
2400	14780	.360	716	6.53	751	7.31	817	8.84	880	10.4	936	12.0	989	13.5
2500	15400	.390	729	7.08	765	7.86	831	9.46	892	11.1	948	12.7	1000	14.3
2600	16020	.422	745	7.61	779	8.43	845	10.1	905	11.8	960	13.4	1012	15.2
2700	16630	.455	759	8.17	792	9.03	859	10.8	917	12.5	972	14.2	1025	16.0
2800	17250	.489	774	8.78	806	9.68	872	11.5	931	13.3	985	15.1	1037	16.9
2900	17860	.525	788	9.41	822	10.4	885	12.2	943	14.0	997	15.9	1049	17.8
3000	18480	.560	803	10.1	837	11.1	899	13.0	957	14.9	1009	16.8	1060	18.7
3200	19710	.638	834	11.4	866	12.6	928	14.7	983	16.7	1037	18.7	1086	20.8
3400	20940	.721	863	13.0	896	14.2	957	16.5	1012	18.6	1063	20.8	1111	23.0

NO. 7 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES
AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1000	7140	.063	287	.60	324	.78	356	.97	387	1.16	414	1.35	440	1.53	466	1.84
1100	7860	.076	300	.71	337	.91	369	1.12	397	1.33	424	1.53	449	1.75	473	1.94
1200	8580	.090	313	.84	350	1.06	380	1.28	407	1.51	434	1.74	459	1.97	483	2.18
1300	9290	.106	327	.98	363	1.23	392	1.46	420	1.71	446	1.95	470	2.20	493	2.44
1400	10000	.122	342	1.14	376	1.41	404	1.67	432	1.92	457	2.18	480	2.45	503	2.71
1500	10720	.141	357	1.31	389	1.60	419	1.88	444	2.16	469	2.44	491	2.72	514	3.00
1600	11430	.160	372	1.50	403	1.82	432	2.12	457	2.42	480	2.71	503	3.01	526	3.31
1700	12150	.180	387	1.70	417	2.05	444	2.38	470	2.70	493	3.01	516	3.33	539	3.64
1800	12860	.202	402	1.93	432	2.31	459	2.66	483	3.00	507	3.33	529	3.67	550	3.99
1900	13570	.225	416	2.19	446	2.58	473	2.96	497	3.33	520	3.69	542	4.04	563	4.38
2000	14290	.250	432	2.47	460	2.88	487	3.28	510	3.68	533	4.07	554	4.42	574	4.78
2100	15000	.275	449	2.77	474	3.19	502	3.63	524	4.05	547	4.46	567	4.85	587	5.22
2200	15720	.302	464	3.10	490	3.53	516	4.00	539	4.44	560	4.88	582	5.31	602	5.70
2300	16430	.330	482	3.47	506	3.91	530	4.38	553	4.87	574	5.32	596	5.76	616	6.19
2400	17150	.360	497	3.84	521	4.31	546	4.80	567	5.32	589	5.78	609	6.27	629	6.71
2500	17860	.390	514	4.27	537	4.76	560	5.24	583	5.78	603	6.30	623	6.80	642	7.27
2600	18580	.422	530	4.73	553	5.20	574	5.73	597	6.29	619	6.84	636	7.33	656	7.84
2700	19290	.455	547	5.22	570	5.71	590	6.23	611	6.82	633	7.40	650	7.93	670	8.46
2800	20000	.489	563	5.73	586	6.27	607	6.81	627	7.41	647	7.99	664	8.54	684	9.10
2900	20720	.525	582	6.25	603	6.86	623	7.38	643	8.00	662	8.62	680	9.18	699	9.76
3000	21430	.560	599	6.84	619	7.47	639	7.99	657	8.62	677	9.25	696	9.87	713	10.5

NO. 7 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	8580	.090	526	2.62	569	3.10	642	4.26	709	5.54				
1300	9290	.106	536	2.91	576	3.51	649	4.49	714	5.81				
1400	10000	.122	546	3.23	584	3.75	657	4.84	722	6.10	782	7.58	837	9.12
1500	10720	.141	556	3.55	594	4.13	664	5.24	729	6.44	789	7.90	844	9.54
1600	11430	.160	567	3.90	604	4.51	673	5.70	737	6.91	797	8.28	852	9.90
1700	12150	.180	577	4.26	614	4.92	683	6.19	746	7.42	804	8.79	859	10.3
1800	12860	.202	587	4.65	626	5.33	693	6.71	754	8.03	811	9.37	866	10.9
1900	13570	.225	600	5.06	637	5.80	703	7.22	764	8.64	820	10.1	873	11.5
2000	14290	.250	613	5.51	649	6.27	714	7.77	774	9.25	829	10.8	880	12.3
2100	15000	.275	626	5.99	660	6.78	726	8.36	784	9.91	837	11.5	889	13.1
2200	15720	.302	639	6.49	673	7.31	736	8.96	794	10.6	847	12.3	899	13.9
2300	16430	.330	652	7.02	684	7.87	747	9.60	806	11.3	857	13.0	909	14.8
2400	17150	.360	664	7.58	697	8.48	759	10.3	817	12.1	869	13.9	919	15.7
2500	17860	.390	677	8.21	710	9.12	772	11.0	829	12.8	880	14.7	929	16.6
2600	18580	.422	692	8.82	723	9.78	784	11.7	840	13.6	892	15.6	940	17.6
2700	19290	.455	704	9.48	736	10.5	797	12.5	852	14.5	903	16.5	952	18.6
2800	20000	.489	719	10.2	749	11.2	810	13.3	864	15.4	914	17.5	963	19.6
2900	20720	.525	731	10.9	763	12.0	822	14.1	876	16.3	926	18.5	974	20.7
3000	21430	.560	746	11.7	777	12.8	834	15.1	889	17.3	937	19.5	984	21.7
3200	22860	.638	774	13.2	804	14.6	862	17.0	913	19.4	963	21.7	1009	24.1
3400	24290	.721	802	15.1	832	16.4	889	19.1	940	21.6	987	24.1	1032	26.7

NO. 7½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	8200	.063	268	.69	303	.90	332	1.11	361	1.33	387	1.55	411	1.76	435	2.12
1100	9020	.076	280	.82	315	1.05	344	1.28	371	1.53	396	1.76	419	2.00	441	2.23
1200	9840	.090	292	.96	327	1.22	355	1.47	380	1.73	405	1.99	428	2.26	451	2.50
1300	10660	.106	305	1.13	339	1.41	365	1.68	392	1.96	416	2.24	439	2.52	460	2.80
1400	11480	.122	319	1.31	351	1.62	377	1.91	403	2.21	427	2.50	448	2.81	469	3.11
1500	12300	.141	333	1.50	363	1.84	391	2.16	415	2.48	437	2.80	459	3.12	480	3.44
1600	13120	.160	347	1.72	376	2.09	403	2.44	427	2.78	448	3.11	469	3.46	491	3.80
1700	13940	.180	361	1.95	389	2.35	415	2.73	439	3.10	460	3.46	481	3.82	503	4.18
1800	14760	.202	375	2.22	403	2.65	428	3.06	451	3.45	473	3.83	493	4.21	513	4.59
1900	15580	.225	388	2.51	416	2.96	441	3.39	464	3.82	485	4.23	505	4.64	525	5.03
2000	16400	.250	403	2.84	429	3.31	455	3.77	476	4.22	497	4.67	517	5.07	536	5.49
2100	17220	.275	419	3.18	443	3.66	468	4.17	489	4.65	511	5.11	529	5.57	548	6.00
2200	18050	.302	433	3.56	457	4.05	481	4.59	503	5.09	523	5.60	543	6.10	561	6.54
2300	18860	.330	449	3.98	472	4.49	495	5.02	516	5.59	536	6.11	556	6.61	575	7.11
2400	19680	.360	464	4.41	487	4.95	509	5.51	529	6.10	549	6.64	568	7.20	587	7.71
2500	20500	.390	480	4.90	501	5.46	523	6.02	544	6.64	563	7.24	581	7.81	599	8.34
2600	21320	.422	495	5.43	516	5.97	536	6.58	557	7.22	577	7.85	593	8.42	612	9.00
2700	22150	.455	511	5.99	532	6.55	551	7.15	571	7.83	591	8.50	607	9.10	625	9.71
2800	22960	.489	525	6.58	547	7.20	567	7.82	585	8.51	604	9.18	620	9.80	639	10.5
2900	23780	.525	543	7.18	563	7.87	581	8.47	600	9.19	617	9.90	635	10.5	652	11.2
3000	24600	.560	559	7.85	577	8.57	596	9.17	613	9.90	632	10.6	649	11.3	665	12.0

NO. 7½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼″ S. P.		1½″ S. P.		2″ S. P.		2½″ S. P.		3″ S. P.		3½″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	9840	.090	491	3.01	531	3.56	599	4.89	661	6.36				
1300	10660	.106	500	3.34	537	4.03	605	5.15	667	6.67				
1400	11480	.122	509	3.70	545	4.30	613	5.56	673	7.00	729	8.70	781	10.5
1500	12300	.141	519	4.08	555	4.74	620	6.02	680	7.40	736	9.07	788	11.0
1600	13120	.160	529	4.48	564	5.18	628	6.54	688	7.93	744	9.51	795	11.4
1700	13940	.180	539	4.89	573	5.64	637	7.11	696	8.52	751	10.1	801	11.8
1800	14760	.202	548	5.34	584	6.12	647	7.70	704	9.22	757	10.8	808	12.5
1900	15580	.225	560	5.81	595	6.66	656	8.29	713	9.91	765	11.6	815	13.2
2000	16400	.250	572	6.33	605	7.20	667	8.92	723	10.6	773	12.4	821	14.1
2100	17220	.275	584	6.88	616	7.78	677	9.59	732	11.4	781	13.2	829	15.0
2200	18050	.302	596	7.45	628	8.39	687	10.3	741	12.2	791	14.1	839	16.0
2300	18860	.330	608	8.06	639	9.03	697	11.0	752	13.0	800	15.0	848	17.0
2400	19680	.360	620	8.70	651	9.71	708	11.8	763	13.8	811	15.9	857	18.0
2500	20500	.390	632	9.42	663	10.5	720	12.6	773	14.7	821	16.9	867	19.1
2600	21320	.422	645	10.1	675	11.2	732	13.5	784	15.7	832	17.9	877	20.2
2700	22150	.455	657	10.9	687	12.0	744	14.4	795	16.6	843	19.0	888	21.3
2800	22960	.489	671	11.7	699	12.9	756	15.3	807	17.6	853	20.1	899	22.5
2900	23780	.525	683	12.5	712	13.8	767	16.2	817	18.7	864	21.2	909	23.7
3000	24600	.560	696	13.4	725	14.7	779	17.3	829	19.8	875	22.3	919	25.0
3200	26250	.638	723	15.2	751	16.7	804	19.6	852	22.2	899	24.9	941	27.7
3400	27880	.721	748	17.3	776	18.9	829	21.9	877	24.8	921	27.7	963	30.7

NO. 8 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.M.P.	H.P.
1000	9330	.063	251	.78	284	1.03	311	1.27	339	1.51	363	1.76	385	2.00	408	2.41
1100	10270	.076	263	.93	295	1.19	323	1.46	348	1.74	371	2.00	393	2.28	414	2.54
1200	11200	.090	274	1.10	306	1.38	333	1.68	356	1.97	380	2.27	401	2.57	423	2.85
1300	12130	.106	286	1.28	318	1.60	343	1.91	368	2.23	390	2.55	411	2.87	431	3.18
1400	13060	.122	299	1.49	329	1.84	354	2.18	378	2.51	400	2.85	420	3.20	440	3.53
1500	14000	.141	313	1.71	340	2.09	366	2.46	389	2.82	410	3.18	430	3.55	450	3.92
1600	14930	.160	325	1.96	353	2.38	378	2.77	400	3.16	420	3.54	440	3.94	460	4.33
1700	15870	.180	339	2.22	365	2.68	389	3.11	411	3.53	431	3.94	451	4.35	471	4.76
1800	16790	.202	351	2.52	378	3.02	401	3.48	423	3.92	444	4.35	463	4.79	481	5.22
1900	17730	.225	364	2.86	390	3.37	414	3.86	435	4.35	455	4.81	474	5.27	493	5.72
2000	18660	.250	378	3.23	403	3.76	426	4.29	446	4.80	466	5.31	485	5.77	503	6.25
2100	19600	.275	393	3.62	415	4.17	439	4.74	459	5.29	479	5.82	496	6.34	514	6.82
2200	20530	.302	406	4.05	429	4.61	451	5.22	471	5.79	490	6.37	509	6.95	526	7.44
2300	21460	.330	421	4.53	443	5.11	464	5.72	484	6.36	503	6.95	521	7.52	539	8.09
2400	22390	.360	435	5.02	456	5.63	478	6.27	496	6.95	515	7.55	533	8.19	550	8.77
2500	23330	.390	450	5.58	470	6.22	490	6.85	510	7.55	528	8.24	545	8.88	561	9.49
2600	24260	.422	464	6.18	484	6.80	503	7.49	523	8.21	541	8.94	556	9.57	574	10.3
2700	25200	.455	479	6.82	499	7.46	516	8.14	535	8.91	554	9.67	569	10.4	586	11.1
2800	26120	.489	493	7.49	513	8.19	531	8.90	549	9.68	566	10.4	581	11.2	599	11.9
2900	27060	.525	509	8.17	528	8.95	545	9.63	563	10.5	579	11.3	595	12.0	611	12.8
3000	28000	.560	524	8.93	541	9.76	559	10.4	575	11.3	593	12.1	609	12.9	624	13.7

NO. 8 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼″ S. P.		1½″ S. P.		2″ S. P.		2½″ S. P.		3″ S. P.		3½″ S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	11200	.090	460	3.43	498	4.05	561	5.57	620	7.23				
1300	12130	.106	469	3.80	504	4.58	568	5.86	625	7.59				
1400	13060	.122	478	4.21	511	4.90	575	6.32	631	7.97	684	9.90	733	11.9
1500	14000	.141	486	4.64	520	5.39	581	6.85	638	8.42	690	10.3	739	12.5
1600	14930	.160	496	5.10	529	5.89	589	7.44	645	9.02	698	10.8	745	12.9
1700	15870	.180	505	5.57	538	6.42	598	8.08	653	9.70	704	11.5	751	13.5
1800	16790	.202	514	6.07	548	6.96	606	8.76	660	10.5	710	12.2	758	14.2
1900	17730	.225	525	6.61	558	7.57	615	9.43	669	11.3	718	13.2	764	15.1
2000	18660	.250	536	7.20	568	8.19	625	10.2	678	12.1	725	14.1	770	16.0
2100	19600	.275	548	7.82	578	8.85	635	10.9	686	13.0	733	15.0	778	17.1
2200	20530	.302	559	8.47	589	9.54	644	11.7	695	13.8	741	16.0	786	18.2
2300	21460	.330	570	9.16	599	10.3	654	12.6	705	14.7	750	17.0	795	19.3
2400	22390	.360	581	9.90	610	11.1	664	13.4	715	15.8	760	18.1	804	20.5
2500	23330	.390	593	10.7	621	11.9	675	14.3	725	16.8	770	19.2	812	21.7
2600	24260	.422	605	11.5	633	12.8	686	15.3	735	17.8	780	20.4	823	23.0
2700	25200	.455	616	12.4	644	13.7	698	16.3	745	18.9	790	21.6	833	24.2
2800	26120	.489	629	13.3	655	14.7	709	17.4	756	20.1	800	22.9	843	25.6
2900	27060	.525	640	14.3	668	15.7	719	18.5	766	21.3	810	24.1	853	27.0
3000	28000	.560	653	15.2	680	16.7	730	19.7	778	22.5	820	25.4	861	28.4
3200	29860	.638	678	17.3	704	19.0	754	22.3	799	25.3	843	28.4	883	31.5
3400	31730	.721	701	19.7	728	21.5	778	24.9	822	28.2	864	31.5	903	34.9

NO. 8½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R. P. M.	H.P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1000	10530	.063	237	.88	267	1.16	293	1.43	319	1.71	341	1.99	362	2.26	384	2.72
1100	11590	.076	247	1.05	278	1.34	304	1.65	327	1.96	350	2.26	370	2.57	390	2.86
1200	12640	.090	258	1.24	288	1.56	313	1.89	335	2.23	358	2.56	378	2.90	398	3.22
1300	13690	.106	270	1.45	299	1.81	322	2.15	346	2.52	367	2.88	387	3.24	406	3.59
1400	14750	.122	281	1.68	310	2.07	333	2.46	355	2.83	377	3.22	395	3.61	414	3.99
1500	15800	.141	294	1.93	320	2.36	345	2.78	366	3.19	386	3.59	405	4.01	424	4.42
1600	16860	.160	306	2.21	332	2.68	355	3.13	377	3.57	395	4.00	414	4.44	433	4.89
1700	17910	.180	319	2.51	344	3.02	366	3.51	387	3.98	406	4.44	425	4.91	444	5.37
1800	18960	.202	331	2.85	355	3.40	378	3.92	398	4.43	418	4.91	435	5.41	453	5.89
1900	20010	.225	342	3.22	367	3.80	390	4.36	410	4.91	428	5.43	446	5.95	464	6.46
2000	21070	.250	355	3.64	379	4.25	401	4.84	420	5.42	439	6.00	457	6.52	473	7.05
2100	22120	.275	369	4.09	391	4.70	413	5.35	432	5.98	451	6.57	467	7.15	484	7.70
2200	23180	.302	382	4.57	404	5.20	425	5.90	444	6.54	461	7.19	479	7.83	495	8.40
2300	24230	.330	397	5.11	417	5.77	437	6.45	455	7.18	473	7.85	491	8.49	507	9.13
2400	25280	.360	410	5.67	430	6.36	450	7.08	467	7.84	485	8.53	501	9.24	518	9.90
2500	26340	.390	424	6.29	442	7.02	461	7.73	480	8.53	497	9.30	513	10.0	528	10.7
2600	27390	.422	437	6.97	455	7.67	473	8.45	492	9.27	510	10.1	524	10.8	540	11.6
2700	28450	.455	451	7.70	470	8.42	486	9.18	504	10.1	521	10.9	535	11.7	552	12.5
2800	29490	.489	464	8.45	482	9.25	500	10.0	517	10.9	533	11.8	547	12.6	564	13.4
2900	30550	.525	479	9.22	497	10.1	513	10.9	530	11.8	545	12.7	560	13.5	576	14.4
3000	31600	.560	493	10.1	510	11.0	526	11.8	541	12.7	558	13.7	573	14.6	587	15.5

NO. 8½ TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1200	12640	.090	433	3.87	468	4.57	528	6.29	584	[illegible].16				
1300	13690	.106	441	4.29	474	5.17	534	6.62	588	8.57				
1400	14750	.122	449	4.76	481	5.53	541	7.14	594	9.00	644	11.2	690	13.4
1500	15800	.141	458	5.24	490	6.08	547	7.73	600	9.50	650	11.7	695	14.1
1600	16860	.160	467	5.75	498	6.65	554	8.40	607	10.2	657	12.2	701	14.6
1700	17910	.180	475	6.29	506	7.25	563	9.13	614	11.0	662	13.0	707	15.2
1800	18960	.202	484	6.86	515	7.86	571	9.89	621	11.8	668	13.8	713	16.0
1900	20010	.225	494	7.46	525	8.55	579	10.7	630	12.7	675	14.9	719	17.0
2000	21070	.250	505	8.13	534	9.25	588	11.5	638	13.7	682	15.9	725	18.1
2100	22120	.275	515	8.83	544	9.99	598	12.3	646	14.6	690	17.0	732	19.3
2200	23180	.302	526	9.57	554	10.8	606	13.2	654	15.6	698	18.1	740	20.5
2300	24230	.330	537	10.4	564	11.6	615	14.2	664	16.6	706	19.2	748	21.8
2400	25280	.360	547	11.2	574	12.5	625	15.1	673	17.8	715	20.5	757	23.1
2500	26340	.390	558	12.1	585	13.5	635	16.2	683	18.9	725	21.7	765	24.5
2600	27390	.422	570	13.0	595	14.4	646	17.3	692	20.1	734	23.0	774	25.9
2700	28450	.455	580	14.0	606	15.4	657	18.4	701	21.4	744	24.4	784	27.4
2800	29490	.489	592	15.0	617	16.6	667	19.6	712	22.7	753	25.8	793	28.9
2900	30550	.525	602	16.1	628	17.7	677	20.9	721	24.0	762	27.3	802	30.5
3000	31600	.560	614	17.2	640	18.9	687	22.3	732	25.4	772	28.7	811	32.1
3200	33710	.638	638	19.5	662	21.5	710	25.1	752	28.5	793	32.0	831	35.6
3400	35810	.721	660	22.2	685	24.2	732	28.1	774	31.8	813	35.6	850	39.4

NO. 9 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	11810	.063	223	.99	252	1.30	277	1.60	301	1.91	322	2.23	342	2.54	362	3.05
1100	12990	.076	233	1.18	262	1.51	287	1.85	309	2.20	330	2.54	349	2.88	368	3.21
1200	14170	.090	243	1.39	272	1.75	296	2.12	317	2.50	338	2.87	357	3.25	376	3.61
1300	15350	.106	255	1.62	282	2.03	305	2.41	327	2.82	347	3.22	366	3.63	383	4.03
1400	16530	.122	266	1.88	292	2.33	315	2.76	336	3.18	356	3.60	373	4.05	391	4.47
1500	17710	.141	278	2.16	302	2.65	326	3.11	346	3.57	365	4.03	382	4.50	400	4.96
1600	18900	.160	289	2.48	313	3.01	336	3.51	356	4.00	373	4.48	391	4.98	409	5.48
1700	20080	.180	301	2.81	324	3.39	346	3.93	366	4.46	383	4.98	401	5.50	419	6.02
1800	21250	.202	312	3.19	336	3.82	357	4.40	376	4.97	395	5.51	411	6.06	428	6.60
1900	22440	.225	323	3.61	347	4.26	368	4.89	387	5.50	405	6.09	421	6.68	438	7.24
2000	23620	.250	336	4.08	358	4.76	379	5.43	397	6.08	415	6.72	431	7.31	447	7.91
2100	24800	.275	349	4.59	369	5.27	390	6.00	408	6.70	426	7.36	441	8.02	457	8.64
2200	25990	.302	361	5.12	381	5.83	401	6.61	419	7.33	436	8.06	452	8.78	468	9.42
2300	27160	.330	375	5.73	393	6.47	412	7.23	430	8.04	447	8.80	463	9.52	479	10.2
2400	28350	.360	387	6.35	406	7.13	425	7.94	441	8.79	458	9.56	475	10.4	489	11.1
2500	29520	.390	400	7.06	418	7.87	436	8.67	453	9.56	469	10.4	485	11.3	499	12.0
2600	30710	.422	412	7.82	430	8.60	447	9.48	465	10.4	481	11.3	495	12.1	510	13.0
2700	31890	.455	426	8.63	443	9.44	459	10.3	476	11.3	492	12.2	506	13.1	521	14.0
2800	33060	.489	438	9.48	456	10.4	472	11.3	488	12.3	503	13.2	517	14.1	532	15.1
2900	34250	.525	452	10.3	469	11.3	485	12.2	500	13.2	515	14.3	529	15.2	543	16.1
3000	35430	.560	466	11.3	481	12.4	497	13.2	511	14.3	527	15.3	541	16.3	555	17.3

NO. 9 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	14170	.090	409	4.33	442	5.12	499	7.05	551	9.15				
1300	15350	.106	417	4.81	448	5.80	505	7.42	556	9.61				
1400	16530	.122	425	5.33	455	6.20	511	8.00	561	10.1	608	12.5	651	15.1
1500	17710	.141	432	5.87	462	6.82	517	8.67	567	10.7	613	13.1	657	15.8
1600	18900	.160	441	6.45	470	7.45	523	9.42	573	11.4	620	13.7	662	16.4
1700	20080	.180	449	7.05	478	8.12	531	10.2	580	12.3	626	14.5	668	17.0
1800	21250	.202	457	7.69	487	8.81	539	11.1	587	13.3	631	15.5	673	18.0
1900	22440	.225	467	8.37	496	9.58	547	11.9	595	14.3	638	16.6	679	19.0
2000	23620	.250	477	9.11	505	10.4	556	12.8	602	15.3	645	17.8	685	20.3
2100	24800	.275	487	9.90	513	11.2	565	13.8	610	16.4	651	19.0	691	21.6
2200	25990	.302	497	10.7	523	12.1	572	14.8	618	17.5	659	20.3	699	23.0
2300	27160	.330	507	11.6	532	13.0	581	15.9	627	18.7	667	21.6	707	24.4
2400	28350	.360	517	12.6	542	14.0	590	17.0	636	19.9	676	22.9	715	25.9
2500	29520	.390	527	13.6	552	15.1	600	18.1	645	21.2	685	24.3	722	27.5
2600	30710	.422	538	14.6	562	16.2	610	19.4	653	22.5	693	25.8	731	29.1
2700	31890	.455	548	15.7	572	17.3	620	20.7	662	23.9	702	27.3	740	30.7
2800	33060	.489	559	16.8	582	18.6	630	22.0	672	25.4	711	28.9	749	32.4
2900	34250	.525	569	18.0	593	19.9	639	23.3	681	26.9	720	30.5	758	34.2
3000	35430	.560	580	19.3	605	21.2	649	25.0	691	28.5	729	32.2	766	35.9
3200	37790	.638	602	21.9	626	24.1	670	28.2	710	32.0	749	35.9	785	39.9
3400	40150	.721	623	24.9	647	27.2	691	31.6	731	35.7	768	39.9	802	44.2

NO. 10 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	14580	.063	201	1.22	227	1.60	249	1.98	271	2.36	290	2.75	308	3.13	326	3.76
1100	16040	.076	210	1.45	236	1.86	258	2.28	278	2.71	297	3.13	314	3.56	331	3.96
1200	17500	.090	219	1.71	245	2.16	266	2.62	285	3.08	304	3.54	321	4.01	338	4.45
1300	18950	.106	229	2.00	254	2.50	274	2.98	294	3.48	312	3.98	329	4.48	345	4.97
1400	20410	.122	239	2.32	263	2.87	283	3.40	302	3.92	320	4.45	336	5.00	352	5.52
1500	21870	.141	250	2.67	272	3.27	293	3.84	311	4.41	328	4.97	344	5.55	360	6.12
1600	23330	.160	260	3.06	282	3.71	302	4.33	320	4.94	336	5.53	352	6.15	368	6.76
1700	24790	.180	271	3.47	292	4.18	311	4.85	329	5.51	345	6.15	361	6.79	377	7.43
1800	26240	.202	281	3.94	302	4.71	321	5.43	338	6.13	355	6.80	370	7.48	385	8.15
1900	27700	.225	291	4.46	312	5.26	331	6.03	348	6.79	364	7.52	379	8.24	394	8.94
2000	29160	.250	302	5.04	322	5.88	341	6.70	357	7.50	373	8.30	388	9.02	402	9.76
2100	30620	.275	314	5.66	332	6.51	351	7.41	367	8.27	383	9.09	397	9.90	411	10.7
2200	32080	.302	325	6.32	343	7.20	361	8.16	377	9.05	392	9.95	407	10.8	421	11.6
2300	33530	.330	337	7.07	354	7.98	371	8.93	387	9.93	402	10.9	417	11.8	431	12.6
2400	34990	.360	348	7.84	365	8.80	382	9.80	397	10.9	412	11.8	426	12.8	440	13.7
2500	36450	.390	360	8.71	376	9.71	392	10.7	408	11.8	422	12.9	436	13.9	449	14.8
2600	37910	.422	371	9.65	387	10.6	402	11.7	418	12.8	433	14.0	445	15.0	459	16.0
2700	39370	.455	383	10.7	399	11.7	413	12.7	428	13.9	443	15.1	455	16.2	469	17.3
2800	40820	.489	394	11.7	410	12.8	425	13.9	439	15.1	453	16.3	465	17.4	479	18.6
2900	42280	.525	407	12.8	422	14.0	436	15.1	450	16.3	463	17.6	476	18.7	489	19.9
3000	43740	.560	419	14.0	433	15.2	447	16.3	460	17.6	474	18.9	487	20.2	499	21.4

NO. 10 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.	R.P.M.	H. P.
1200	17500	.090	368	5.35	398	6.32	449	8.70	496	11.3				
1300	18950	.106	375	5.94	403	7.16	454	9.16	500	11.9				
1400	20410	.122	382	6.58	409	7.65	460	9.88	505	12.5	547	15.5	586	18.6
1500	21870	.141	389	7.25	416	8.42	465	10.7	510	13.2	552	16.1	591	19.5
1600	23330	.160	397	7.96	423	9.20	471	11.6	516	14.1	558	16.9	596	20.2
1700	24790	.180	404	8.70	430	10.0	478	12.6	522	15.2	563	17.9	601	21.0
1800	26240	.202	411	9.49	438	10.9	485	13.7	528	16.4	568	19.1	606	22.2
1900	27700	.225	420	10.3	446	11.8	492	14.7	535	17.6	574	20.5	611	23.5
2000	29160	.250	429	11.3	454	12.8	500	15.9	542	18.9	580	22.0	616	25.1
2100	30620	.275	438	12.2	462	13.8	508	17.1	549	20.2	586	23.5	622	26.7
2200	32080	.302	447	13.2	471	14.9	515	18.3	556	21.6	593	25.0	629	28.4
2300	33530	.330	456	14.3	479	16.1	523	19.6	564	23.0	600	26.6	636	30.1
2400	34990	.360	465	15.5	488	17.3	531	20.9	572	24.6	608	28.3	643	32.0
2500	36450	.390	474	16.8	497	18.6	540	22.4	580	26.2	616	30.0	650	33.9
2600	37910	.422	484	18.0	506	20.0	549	23.9	588	27.8	624	31.8	658	35.9
2700	39370	.455	493	19.3	515	21.4	558	25.5	596	29.6	632	33.7	666	37.9
2800	40820	.489	503	20.8	524	22.9	567	27.1	605	31.4	640	35.7	674	40.0
2900	42280	.525	512	22.3	534	24.5	575	28.9	613	33.2	648	37.7	682	42.2
3000	43740	.560	522	23.8	544	26.2	584	30.8	622	35.2	656	39.7	689	44.4
3200	46650	.638	542	27.0	563	29.7	603	34.8	639	39.5	674	44.3	706	49.2
3400	49570	.721	561	30.7	582	33.5	622	39.0	658	44.0	691	49.2	722	54.5

NO. 11 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	17640	.063	183	1.48	206	1.94	226	2.40	246	2.86	264	3.33	280	3.79	296	4.55
1100	19410	.076	191	1.76	215	2.25	235	2.76	253	3.28	270	3.79	286	4.31	301	4.79
1200	21170	.090	199	2.07	223	2.61	242	3.17	259	3.73	278	4.28	292	4.85	307	5.39
1300	22930	.106	208	2.42	231	3.03	249	3.61	267	4.21	284	4.82	299	5.42	314	6.01
1400	24700	.122	217	2.81	239	3.47	257	4.11	275	4.74	291	5.39	306	6.05	320	6.68
1500	26460	.141	227	3.23	247	3.96	266	4.65	283	5.34	298	6.01	313	6.72	327	7.41
1600	28230	.160	236	3.70	256	4.49	275	5.24	291	5.98	306	6.69	320	7.44	335	8.18
1700	30000	.180	246	4.20	266	5.06	283	5.87	299	6.67	314	7.44	328	8.22	343	8.99
1800	31750	.202	256	4.77	275	5.70	292	6.57	307	7.42	323	8.23	336	9.05	350	9.86
1900	33520	.225	265	5.40	284	6.37	301	7.30	316	8.22	331	9.10	345	9.97	358	10.8
2000	35280	.250	275	6.10	293	7.12	310	8.11	325	9.08	339	10.1	353	10.9	365	11.8
2100	37050	.275	286	6.85	302	7.88	319	8.97	334	10.0	348	11.0	361	12.0	374	12.9
2200	38820	.302	296	7.65	312	8.71	328	9.87	343	11.0	356	12.1	370	13.1	383	14.1
2300	40570	.330	306	8.56	322	9.66	337	10.8	352	12.0	366	13.1	379	14.2	392	15.3
2400	42340	.360	316	9.49	332	10.7	347	11.9	361	13.1	375	14.3	387	15.5	400	16.6
2500	44100	.390	327	10.5	342	11.8	356	13.0	371	14.3	384	15.6	396	16.8	408	18.0
2600	45870	.422	337	11.7	352	12.9	366	14.2	380	15.5	394	16.9	405	18.1	417	19.4
2700	47640	.455	348	12.9	363	14.1	376	15.4	389	16.9	403	18.3	414	19.6	426	20.9
2800	49390	.489	358	14.2	373	15.5	386	16.8	399	18.3	412	19.7	423	21.1	436	22.5
2900	51160	.525	370	15.4	384	16.9	396	18.2	409	19.8	421	21.3	433	22.7	445	24.1
3000	52920	.560	381	16.9	394	18.5	406	19.7	418	21.3	431	22.9	443	24.4	454	25.9

NO. 11 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼″ S. P.		1½″ S. P.		2″ S. P.		2½″ S. P.		3″ S. P.		3½″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	21170	.090	335	6.47	362	7.65	408	10.5	451	13.7				
1300	22930	.106	341	7.19	366	8.66	413	11.1	455	14.4				
1400	24700	.122	347	7.96	372	9.26	418	12.0	459	15.1	497	18.7	533	22.5
1500	26640	.141	354	8.77	378	10.2	423	13.0	464	15.9	502	19.5	537	23.6
1600	28230	.160	361	9.63	385	11.1	428	14.1	469	17.1	507	20.5	542	24.5
1700	30000	.180	367	10.5	391	12.1	435	15.3	475	18.3	512	21.7	546	25.5
1800	31750	.202	374	11.5	398	13.2	441	16.6	480	19.8	516	23.1	551	26.8
1900	33520	.225	382	12.5	406	14.3	447	17.8	486	21.3	522	24.9	556	28.4
2000	35280	.250	390	13.6	413	15.5	455	19.2	493	22.9	527	26.6	560	30.3
2100	37050	.275	398	14.8	420	16.7	462	20.6	499	24.5	533	28.4	566	32.3
2200	38820	.302	406	16.0	428	18.1	468	22.1	506	26.2	539	30.3	572	34.3
2300	40570	.330	416	17.3	436	19.4	476	23.7	513	27.9	546	32.2	578	36.5
2400	42350	.360	423	18.7	444	20.9	483	25.3	520	29.8	553	34.3	585	38.7
2500	44100	.390	431	20.3	452	22.5	491	27.1	527	31.7	560	36.3	591	41.0
2600	45870	.422	440	21.8	460	24.1	499	28.9	535	33.7	567	38.5	598	43.4
2700	47640	.455	448	23.4	468	25.9	507	30.9	542	35.8	575	40.8	606	45.8
2800	49390	.489	457	25.2	476	27.7	515	32.8	550	37.9	582	43.2	613	48.4
2900	51160	.525	466	27.0	486	29.7	523	34.9	557	40.2	589	45.6	620	51.0
3000	52920	.560	475	28.8	495	31.7	531	37.3	566	42.6	596	48.0	626	53.7
3200	56460	.638	493	32.7	512	35.9	548	42.1	581	47.8	613	53.6	642	59.5
3400	59980	.721	510	37.2	529	40.5	566	47.1	598	53.2	628	59.5	656	66.0

NO. 12 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	21000	.063	168	1.76	189	2.30	208	2.85	226	3.40	242	3.96	257	4.51	272	5.42
1100	23100	.076	175	2.09	197	2.68	215	3.28	232	3.90	248	4.51	262	5.13	276	5.70
1200	25200	.090	183	2.45	204	3.11	222	3.77	238	4.44	253	5.10	268	5.78	282	6.41
1300	27290	.106	191	2.88	212	3.60	228	4.29	245	5.01	260	5.73	274	6.45	288	7.16
1400	29390	.122	199	3.34	219	4.13	236	4.90	252	5.65	267	6.41	280	7.20	293	7.95
1500	31490	.141	208	3.85	227	4.71	244	5.53	259	6.35	273	7.16	287	7.99	300	8.81
1600	33600	.160	217	4.41	235	5.34	252	6.24	267	7.11	280	7.96	293	8.86	307	9.74
1700	35700	.180	226	5.00	243	6.02	259	6.98	274	7.94	288	8.86	301	9.78	314	10.7
1800	37780	.202	234	5.67	252	6.78	268	7.82	282	8.83	296	9.79	308	10.8	321	11.7
1900	39890	.225	243	6.42	260	7.58	276	8.68	290	9.78	303	10.8	316	11.9	328	12.9
2000	41990	.250	252	7.26	268	8.47	284	9.65	298	10.8	311	12.0	323	13.0	335	14.1
2100	44090	.275	262	8.15	277	9.37	293	10.7	306	11.9	319	13.1	331	14.3	343	15.4
2200	46190	.302	271	9.10	286	10.4	301	11.8	314	13.0	327	14.3	339	15.6	351	16.8
2300	48280	.330	281	10.2	295	11.5	309	12.9	323	14.3	335	15.6	348	16.9	359	18.2
2400	50380	.360	290	11.3	304	12.7	318	14.1	331	15.6	343	17.0	355	18.4	367	19.7
2500	52480	.390	300	12.6	313	14.0	327	15.4	340	17.0	352	18.5	363	20.0	374	21.4
2600	54590	.422	309	13.9	323	15.3	335	16.9	348	18.5	361	20.1	371	21.6	383	23.0
2700	56680	.455	319	15.3	333	16.8	344	18.3	357	20.1	369	21.8	379	23.3	391	24.9
2800	58780	.489	328	16.9	342	18.4	354	20.0	366	21.8	378	23.5	388	25.1	399	26.8
2900	60880	.525	339	18.4	352	20.2	363	21.7	375	23.5	386	25.4	397	27.0	408	28.7
3000	62980	.560	349	20.1	361	22.0	373	23.5	383	25.4	395	27.2	406	29.0	416	30.8

NO. 12 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1200	25200	.090	307	7.71	332	9.1	374	12.5	413	16.3				
1300	27290	.106	313	8.55	336	10.3	378	13.2	417	17.1				
1400	29390	.122	318	9.48	341	11.0	383	14.2	421	17.9	456	22.3	488	26.8
1500	31490	.141	324	10.4	347	12.1	388	15.4	425	18.9	460	23.2	493	28.0
1600	33600	.160	331	11.5	353	13.3	393	16.8	430	20.3	465	24.3	497	29.1
1700	35700	.180	337	12.5	358	14.5	398	18.2	435	21.8	469	25.8	501	30.3
1800	37780	.202	343	13.7	365	15.7	404	19.7	440	23.6	473	27.5	505	31.9
1900	39890	.225	350	14.9	372	17.0	410	21.2	446	25.4	479	29.6	509	33.9
2000	41990	.250	358	16.2	378	18.4	417	22.8	452	27.2	483	31.6	513	36.1
2100	44090	.275	365	17.6	385	19.9	423	24.5	458	29.1	488	33.8	518	38.5
2200	46190	.302	373	19.1	393	21.5	429	26.3	463	31.1	494	36.0	524	40.8
2300	48280	.330	380	20.6	399	23.1	436	28.2	470	33.2	500	38.3	530	43.4
2400	50380	.360	388	22.3	407	24.9	443	30.1	478	35.4	507	40.8	536	46.1
2500	52480	.390	395	24.1	414	26.8	450	32.2	483	37.7	513	43.2	542	48.8
2600	54590	.422	403	25.9	422	28.7	458	34.4	490	40.1	520	45.8	549	51.6
2700	56680	.455	411	27.9	429	30.8	465	36.7	497	42.6	527	48.5	555	54.5
2800	58780	.489	419	29.9	437	33.0	473	39.1	504	45.2	533	51.4	562	57.6
2900	60880	.525	427	32.1	445	35.3	479	41.6	511	47.8	540	54.3	568	60.7
3000	62980	.560	435	34.3	453	37.7	487	44.4	518	50.7	547	57.2	574	63.9
3200	67180	.638	452	38.9	469	42.8	503	50.1	533	56.9	562	63.8	588	70.9
3400	71380	.721	468	44.3	485	48.3	518	56.1	549	63.4	576	70.9	602	78.5

NO. 13 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	24640	.063	155	2.06	175	2.71	192	3.35	209	3.99	223	4.65	237	5.29	251	6.36
1100	27110	.076	162	2.45	182	3.14	198	3.85	214	4.58	229	5.29	242	6.02	255	6.69
1200	29570	.090	169	2.89	189	3.65	205	4.43	219	5.21	234	5.98	247	6.78	260	7.52
1300	32020	.106	176	3.38	196	4.23	211	5.04	226	5.88	240	6.73	253	7.57	265	8.40
1400	34490	.122	184	3.92	202	4.85	218	5.75	232	6.63	246	7.52	259	8.45	270	9.33
1500	36960	.141	192	4.51	209	5.53	225	6.49	239	7.45	252	8.40	265	9.38	277	10.4
1600	39430	.160	200	5.17	217	6.27	232	7.32	246	8.35	259	9.35	271	10.4	283	11.4
1700	41900	.180	209	5.87	225	7.07	239	8.20	253	9.31	265	10.4	278	11.5	290	12.6
1800	44340	.202	216	6.66	232	7.96	247	9.18	260	10.4	273	11.5	285	12.7	296	13.8
1900	46810	.225	224	7.54	240	8.89	255	10.2	268	11.5	280	12.7	292	13.9	303	15.1
2000	49280	.250	232	8.52	248	9.94	262	11.3	275	12.7	287	14.0	299	15.3	309	16.5
2100	51740	.275	242	9.57	255	11.0	270	12.5	282	14.0	295	15.4	305	16.7	316	18.0
2200	54220	.302	250	10.7	264	12.2	278	13.8	290	15.3	302	16.8	313	18.3	324	19.7
2300	56660	.330	259	12.0	272	13.5	285	15.1	298	16.8	309	18.4	321	19.9	332	21.4
2400	59130	.360	268	13.3	281	14.9	294	16.6	305	18.3	317	20.0	328	21.6	339	23.2
2500	61600	.390	277	14.7	289	16.4	302	18.1	314	20.0	325	21.8	335	23.5	346	25.1
2600	64060	.422	286	16.3	298	18.0	309	19.8	322	21.7	333	23.6	342	25.3	353	27.1
2700	66530	.455	295	18.0	307	19.7	318	21.5	329	23.5	341	25.5	350	27.4	361	29.2
2800	68980	.489	303	19.8	315	21.6	327	23.5	338	25.6	349	27.6	358	29.4	369	31.4
2900	71450	.525	313	21.6	325	23.7	335	25.4	346	27.6	356	29.8	366	31.7	376	33.7
3000	73920	.560	322	23.6	333	25.8	344	27.6	354	29.7	365	31.9	375	34.1	384	36.2

NO. 13 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼″ S. P.		1½″ S. P.		2″ S. P.		2½″ S. P.		3″ S. P.		3½″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1200	29570	.090	283	9.04	306	10.7	346	14.7	382	19.1				
1300	32020	.106	289	10.0	310	12.1	349	15.5	385	20.1				
1400	34490	.122	294	11.1	315	12.9	354	16.7	389	21.1	421	26.1	451	31.4
1500	36960	.141	299	12.3	320	14.2	358	18.1	392	22.2	425	27.3	455	32.9
1600	39430	.160	305	13.5	325	15.6	362	19.7	397	23.8	429	28.6	459	34.1
1700	41900	.180	311	14.7	331	17.0	368	21.4	402	25.6	433	30.3	462	35.6
1800	44340	.202	316	16.0	337	18.4	373	23.1	406	27.7	437	32.3	466	37.4
1900	46810	.225	323	17.5	343	20.0	379	24.9	412	29.8	442	34.7	470	39.7
2000	49280	.250	330	19.0	349	21.6	385	26.8	417	31.9	446	37.1	474	42.3
2100	51740	.275	337	20.7	356	23.4	391	28.8	422	34.2	451	39.7	479	45.1
2200	54220	.302	344	22.4	362	25.2	396	30.9	428	36.5	456	42.3	484	47.9
2300	56660	.330	351	24.2	369	27.2	402	33.1	434	38.9	462	45.0	489	50.9
2400	59130	.360	358	26.1	375	29.2	409	35.4	440	41.6	468	47.8	495	54.1
2500	61600	.390	365	28.3	382	31.5	415	37.8	446	44.3	474	50.7	500	57.3
2600	64060	.422	372	30.4	389	33.7	422	40.4	452	47.0	480	53.8	506	60.6
2700	66530	.455	379	32.7	396	36.1	429	43.1	459	49.0	486	57.0	512	64.0
2800	68980	.489	387	35.1	403	38.7	436	45.8	465	53.0	492	60.3	519	67.6
2900	71450	.525	394	37.6	411	41.4	442	48.8	472	56.1	499	63.7	525	71.2
3000	73920	.560	402	40.2	419	44.2	449	52.1	479	59.5	505	67.1	530	75.0
3200	78830	.638	417	45.7	433	50.2	464	58.7	492	66.7	519	74.9	543	83.2
3400	83770	.721	432	52.0	448	56.6	479	65.8	506	74.4	532	83.1	556	92.1

NO. 14 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1000	28580	.063	144	2.39	162	3.14	178	3.88	194	4.63	207	5.39	220	6.14	233	7.37
1100	31440	.076	150	2.84	169	3.65	184	4.47	199	5.31	212	6.14	224	6.98	237	7.76
1200	34300	.090	157	3.35	175	4.23	190	5.14	204	6.04	217	6.94	229	7.86	242	8.72
1300	37140	.106	164	3.92	182	4.90	196	5.84	210	6.82	223	7.80	235	8.78	247	9.74
1400	40000	.122	171	4.55	188	5.63	202	6.67	216	7.68	229	8.72	240	9.80	252	10.8
1500	42870	.141	179	5.23	194	6.41	209	7.53	222	8.64	234	9.74	246	10.9	257	12.0
1600	45730	.160	186	6.00	202	7.27	216	8.49	229	9.68	240	10.8	252	12.1	263	13.3
1700	48590	.180	194	6.80	209	8.19	222	9.51	235	10.8	246	12.1	258	13.3	269	14.6
1800	51430	.202	201	7.72	216	9.23	229	10.7	242	12.0	254	13.3	264	14.7	275	16.0
1900	54300	.225	208	8.74	223	10.3	236	11.8	249	13.3	260	14.7	271	16.2	282	17.5
2000	57150	.250	216	9.88	230	11.5	244	13.1	255	14.7	267	16.3	277	17.7	287	19.1
2100	60020	.275	224	11.1	237	12.8	251	14.5	262	16.2	274	17.8	284	19.4	294	20.9
2200	62870	.302	232	12.4	245	14.1	258	16.0	269	17.7	280	19.5	291	21.3	301	22.8
2300	65720	.330	241	13.9	253	15.7	265	17.5	277	19.5	287	21.3	298	23.0	308	24.8
2400	68580	.360	249	15.4	261	17.3	273	19.2	284	21.3	294	23.1	304	25.1	314	26.9
2500	71440	.390	257	17.1	269	19.0	280	21.0	292	23.1	302	25.2	312	27.2	321	29.1
2600	74300	.422	265	18.9	277	20.8	287	22.9	299	25.2	309	27.4	318	29.3	328	31.4
2700	77170	.455	274	20.9	285	22.8	295	24.9	306	27.3	317	29.6	325	31.7	335	33.8
2800	80000	.489	282	22.9	293	25.1	304	27.2	314	29.7	324	32.0	332	34.2	342	36.4
2900	82870	.525	291	25.0	302	27.4	312	29.5	322	32.0	331	34.5	340	36.7	349	39.0
3000	85730	.560	299	27.4	309	29.9	319	32.0	329	34.5	339	37.0	348	39.5	357	42.0

NO. 14 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H.P.
1200	34300	.090	263	10.5	284	12.4	321	17.1	354	22.2				
1300	37140	.106	268	11.7	288	14.0	324	18.0	357	23.3				
1400	40000	.122	273	12.9	292	15.0	329	19.4	361	24.4	391	30.3	419	36.5
1500	42870	.141	278	14.2	297	16.5	332	21.0	364	25.8	394	31.6	422	38.2
1600	45730	.160	284	15.6	302	18.0	337	22.8	369	27.6	399	33.1	426	39.6
1700	48590	.180	289	17.1	307	19.7	342	24.8	373	29.7	402	35.2	429	41.2
1800	51430	.202	294	18.6	313	21.3	347	26.8	377	32.1	406	37.5	433	43.4
1900	54300	.225	300	20.3	319	23.2	352	28.9	382	34.5	410	40.3	437	46.1
2000	57150	.250	307	22.1	324	25.1	357	31.1	387	37.0	414	43.1	440	49.1
2100	60020	.275	313	24.0	330	27.1	363	33.4	392	39.7	419	46.0	444	52.3
2200	62870	.302	319	26.0	337	29.2	368	35.8	397	42.4	424	49.1	449	55.6
2300	65720	.330	326	28.1	342	31.5	374	38.4	403	45.1	429	52.1	454	59.0
2400	68580	.360	332	30.3	349	33.9	379	41.0	410	48.2	434	55.5	459	62.7
2500	71440	.390	339	32.8	355	36.5	386	43.9	414	51.4	440	58.8	464	66.5
2600	74300	.422	346	35.3	362	39.1	392	46.9	420	54.5	446	62.3	470	70.3
2700	77170	.455	352	37.9	368	41.9	399	50.0	426	57.9	452	66.1	476	74.2
2800	80000	.489	359	40.8	374	44.9	405	53.2	432	61.5	457	70.0	482	78.4
2900	82870	.525	366	43.7	382	48.0	411	56.6	438	65.1	463	73.9	487	82.6
3000	85730	.560	373	46.7	389	51.3	417	60.4	444	69.0	469	77.8	492	86.9
3200	91440	.638	387	53.0	402	58.2	431	68.1	457	77.4	482	86.8	504	96.4
3400	97160	.721	401	60.3	416	65.7	444	76.4	470	86.3	494	96.4	516	106.8

NO. 15 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼" S. P.		⅜" S. P.		½" S. P.		⅝" S. P.		¾" S. P.		⅞" S. P.		1" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	32800	.063	134	2.75	151	3.60	166	4.46	181	5.31	193	6.19	205	7.04	217	8.46
1100	36090	.076	140	3.26	157	4.19	172	5.13	185	6.10	198	7.04	209	8.01	221	8.91
1200	39370	.090	146	3.85	163	4.86	177	5.90	190	6.93	203	7.97	214	9.02	225	10.0
1300	42650	.106	153	4.50	169	5.63	183	6.71	196	7.83	208	8.96	219	10.1	230	11.2
1400	45920	.122	159	5.22	175	6.46	189	7.65	201	8.82	213	10.0	224	11.3	235	12.4
1500	49200	.141	167	6.01	181	7.36	195	8.64	207	9.92	219	11.2	229	12.5	240	13.8
1600	52490	.160	173	6.89	188	8.35	201	9.74	213	11.1	224	12.5	235	13.8	245	15.2
1700	55780	.180	181	7.81	195	9.41	207	10.9	219	12.4	230	13.8	241	15.3	251	16.7
1800	59040	.202	187	8.87	201	10.6	214	12.2	225	13.8	237	15.3	247	16.8	257	18.3
1900	62320	.225	194	10.0	208	11.8	221	13.6	232	15.3	243	16.9	253	18.5	263	20.1
2000	65600	.250	201	11.4	215	13.2	227	15.1	238	16.9	249	18.7	259	20.3	268	22.0
2100	68900	.275	209	12.7	221	14.7	234	16.7	245	18.6	255	20.5	265	22.3	274	24.0
2200	72180	.302	217	14.2	229	16.2	241	18.4	251	20.4	261	22.4	271	24.4	281	26.2
2300	75440	.330	225	15.9	236	18.0	247	20.1	258	22.4	268	24.4	278	26.4	287	28.4
2400	78720	.360	232	17.7	243	19.8	255	22.1	265	24.4	275	26.6	284	28.8	293	30.8
2500	82000	.390	240	19.6	251	21.9	261	24.1	272	26.6	281	29.0	291	31.2	299	33.4
2600	85300	.422	247	21.7	258	23.9	268	26.3	279	28.9	289	31.4	297	33.7	306	36.0
2700	88580	.455	255	24.0	266	26.2	275	28.6	285	31.3	295	34.0	303	36.4	313	38.8
2800	91840	.489	263	26.3	273	28.8	283	31.3	293	34.1	302	36.7	310	39.2	319	41.8
2900	95120	.525	271	28.7	281	31.5	291	33.9	300	36.8	309	39.6	317	42.2	326	44.8
3000	98410	.560	279	31.4	289	34.3	298	36.7	307	39.6	316	42.5	325	45.3	333	48.2

NO. 15 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

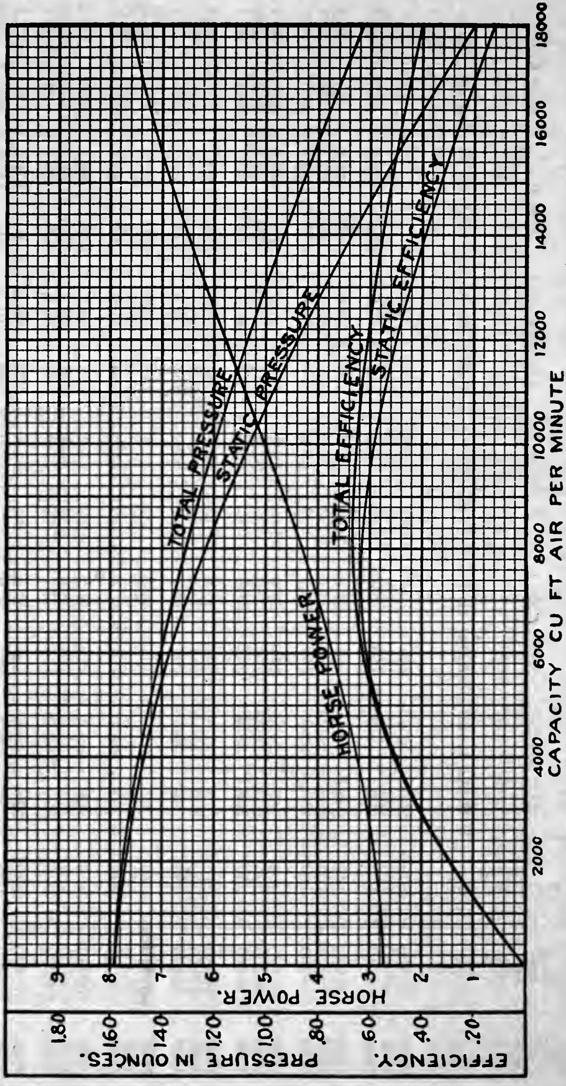
Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1200	39370	.090	245	12.0	265	14.2	299	19.6	331	25.4				
1300	42650	.106	250	13.4	269	16.1	303	20.6	333	26.7				
1400	45920	.122	255	14.8	273	17.2	307	22.2	337	28.0	365	34.8	391	41.9
1500	49200	.141	259	16.3	277	19.0	310	24.1	340	29.6	368	36.3	394	43.8
1600	52490	.160	265	17.9	282	20.7	314	26.2	344	31.7	372	38.0	397	45.5
1700	55780	.180	269	19.6	287	22.6	319	28.4	348	34.1	375	40.4	401	47.3
1800	59040	.202	274	21.4	292	24.5	323	30.8	352	36.9	379	43.0	404	49.8
1900	62320	.225	280	23.3	297	26.6	328	33.2	357	39.7	383	46.2	407	52.9
2000	65600	.250	286	25.3	303	28.8	333	35.7	361	42.5	387	49.4	411	56.4
2100	68900	.275	292	27.5	308	31.1	339	38.4	366	45.5	391	52.8	415	60.1
2200	72180	.302	298	29.8	314	33.6	343	41.1	371	48.7	395	56.3	419	63.8
2300	75440	.330	304	32.2	319	36.1	349	44.1	376	51.8	400	59.9	424	67.8
2400	78720	.360	310	34.8	325	38.9	354	47.1	381	55.4	405	63.7	429	72.0
2500	82000	.390	316	37.7	331	41.9	360	50.4	387	59.0	411	67.5	433	76.3
2600	85300	.422	323	40.5	337	44.9	366	53.8	391	62.6	416	71.6	439	80.7
2700	88580	.455	329	43.5	343	48.1	372	57.4	397	66.5	421	75.8	444	85.2
2800	91840	.489	335	46.8	349	51.5	378	61.0	403	70.5	427	80.3	449	90.0
2900	95120	.525	341	50.1	356	55.1	383	64.9	409	74.7	432	84.8	455	94.8
3000	98410	.560	348	53.6	363	58.8	389	69.3	415	79.2	437	89.3	459	99.8
3200	104950	.638	361	60.8	375	66.8	402	78.2	426	88.8	449	99.7	471	110.7
3400	111530	.721	374	69.2	388	75.4	415	87.6	439	99.0	461	110.7	481	122.6

NO. 16 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES
AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	¼″ S. P.		⅜″ S. P.		½″ S. P.		⅝″ S. P.		¾″ S. P.		⅞″ S. P.		1″ S. P.	
			R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.
1000	37320	.063	126	3.12	142	4.10	156	5.07	170	6.04	181	7.04	193	8.01	204	9.63
1100	41060	.076	131	3.71	148	4.76	161	5.84	174	6.94	186	8.01	196	9.11	208	10.1
1200	44800	.090	137	4.38	153	5.53	166	6.71	178	7.89	190	9.06	201	10.3	211	11.4
1300	48510	.106	143	5.12	159	6.40	171	7.63	184	8.91	195	10.2	206	11.5	216	12.7
1400	52240	.122	149	5.94	164	7.35	177	8.70	189	10.0	200	11.4	210	12.8	220	14.1
1500	55980	.141	156	6.84	170	8.37	183	9.83	194	11.3	205	12.7	215	14.2	225	15.7
1600	59720	.160	163	7.83	176	9.50	189	11.1	200	12.7	210	14.2	220	15.8	230	17.3
1700	63460	.180	169	8.88	183	10.7	195	12.4	206	14.1	216	15.8	226	17.4	236	19.0
1800	67170	.202	176	10.1	189	12.1	201	13.9	211	15.7	222	17.4	231	19.2	241	20.9
1900	70900	.225	182	11.4	195	13.5	207	15.4	218	17.4	228	19.3	237	21.1	246	22.9
2000	74640	.250	189	12.9	201	15.1	213	17.2	223	19.2	233	21.3	243	23.1	251	25.0
2100	78380	.275	196	14.5	208	16.7	219	19.0	229	21.2	239	23.3	248	25.4	257	27.3
2200	82120	.302	203	16.2	214	18.4	226	20.9	236	23.2	245	25.5	254	27.8	263	29.8
2300	85830	.330	211	18.1	221	20.4	232	22.9	242	25.4	251	27.8	261	30.1	270	32.4
2400	89570	.360	218	20.1	228	22.5	239	25.1	248	27.8	258	30.2	266	32.7	275	35.1
2500	93300	.390	225	22.3	235	24.9	245	27.4	255	30.2	264	33.0	273	35.5	281	38.0
2600	97040	.422	232	24.7	242	27.2	251	30.0	261	32.9	271	35.7	278	38.3	287	41.0
2700	100780	.455	239	27.3	249	29.8	258	32.5	268	35.6	277	38.7	284	41.4	293	44.2
2800	104500	.489	246	30.0	256	32.8	266	35.6	274	38.7	283	41.8	291	44.6	300	47.6
2900	108230	.525	254	32.7	264	35.8	273	38.5	281	41.8	289	45.1	298	48.0	306	51.0
3000	111970	.560	262	35.7	271	39.0	280	41.7	288	45.1	296	48.3	304	51.6	312	54.8

NO. 16 TURBO-CONOIDAL FAN (TYPE T) CAPACITIES AND STATIC PRESSURES AT 70° F. AND 29.92 INCHES BAROMETER

Outlet Velocity Ft. per Min.	Capacity Cu. Ft. Air per Min.	Add for Total Press.	1¼" S. P.		1½" S. P.		2" S. P.		2½" S. P.		3" S. P.		3½" S. P.	
			R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.	R. P. M.	H. P.
1200	44800	.090	230	13.7	249	16.2	281	22.3	310	28.9				
1300	48510	.106	234	15.2	252	18.3	284	23.5	313	30.4				
1400	52240	.122	239	16.9	256	19.6	288	25.3	316	31.9	342	39.6	366	47.6
1500	55980	.141	243	18.6	260	21.6	291	27.4	319	33.7	345	41.3	370	49.8
1600	59720	.160	248	20.4	264	23.6	294	29.8	323	36.1	349	43.3	373	51.7
1700	63460	.180	253	22.3	269	25.7	299	32.3	326	38.8	352	45.9	376	53.8
1800	67170	.202	257	24.3	274	27.9	303	35.1	330	41.9	355	49.0	379	56.7
1900	70900	.225	263	26.5	279	30.3	308	37.7	334	45.1	359	52.6	382	60.2
2000	74640	.250	268	28.8	284	32.8	312	40.6	339	48.3	363	56.2	385	64.1
2100	78380	.275	274	31.3	289	35.4	318	43.7	343	51.8	366	60.1	389	68.4
2200	82120	.302	280	33.9	294	38.2	322	46.8	348	55.4	371	64.1	393	72.6
2300	85830	.330	285	36.7	299	41.1	327	50.2	353	59.0	375	68.1	398	77.1
2400	89570	.360	291	39.6	305	44.3	332	53.6	358	63.0	380	72.5	402	81.9
2500	93300	.390	296	42.9	311	47.6	338	57.3	363	67.1	385	76.8	406	86.8
2600	97040	.422	303	46.1	316	51.1	343	61.2	368	71.2	390	81.4	411	91.8
2700	100780	.455	308	49.5	322	54.7	349	65.3	373	75.7	395	86.3	416	96.9
2800	104500	.489	314	53.2	328	58.6	354	69.4	378	80.3	400	91.4	421	102.4
2900	108230	.525	320	57.0	334	62.7	360	73.9	383	85.0	405	96.5	426	107.9
3000	111970	.560	326	60.9	340	67.0	365	78.9	389	90.1	410	101.6	431	113.5
3200	119400	.638	339	69.2	352	76.0	377	89.0	400	101.1	421	113.4	441	126.0
3400	126900	.721	351	78.7	364	85.8	389	99.7	411	112.6	432	126.0	451	139.5



TEST OF NO. 6 TURBO-CONOIDAL FAN. 800 R.P.M. 70°F. 29.92" BAROM.

Induced Draft Tables

Induced draft tables are given for both Planoidal and Niagara Conoidal fans, with gases at 300° and 550° Fahr. The 300° tables are to be used in case the gases are passed through an economizer. These tables give the boiler horsepower that will be served, together with the speed, cubic feet of gases handled per minute, and the power required to drive the fan, for different sizes of fans operating at various pressures measured at the breeching of the boiler. Thus, if we operate a 100-inch Planoidal fan handling gases at 550° at 355 R. P. M., and 0.75 inch static pressure, we will be able to develop 670 boiler H. P. In case we speed up to 502 R. P. M., with a pressure of 1.5 inches, we will be able to develop 950 boiler H. P., or an increase of 41 per cent. The power required to drive the fan will increase from 7.06 H. P. to 20.0 H. P.

Special Narrow Induced Draft Fans

The tables of special steel plate fans to be direct connected to Buffalo steam engines and used for induced draft work will be found especially convenient when selecting apparatus for this purpose. The first column gives a number, which refers to that particular combination of engine and fan. It will be noticed that these are narrow, tall fans, of the special high efficiency type, operating at such a speed as to make them suitable for direct connection to steam engines.

These fans are to be operated with a static pressure of 1.69 inches at the breeching of the boiler, with gases at 550°, and develop 50 per cent. overload on the boiler. These combinations are so selected that a peak load on the boiler of at least 100 per cent. may be carried for a limited time, and approximately 50 per cent. overload all of the time. The engines are to be operated at their normal rated cut-off and at the speed indicated, the steam pressure required being indicated in the third column. The above is based on the assumption that under average conditions a pressure of 0.75 in. at the up-take will be required, when operating at normal rated capacity.

300°

INDUCED DRAFT FAN CAPACITIES
BUFFALO PLANOIDAL (TYPE L) EXHAUSTERS WITH ECONOMIZER

Size of Fan	1 In. or 0.577 Oz. Static Press.				1¼ In. or 0.721 Oz. Static Press.				1½ In. or 0.865 Oz. Static Press.			
	Boiler H. P. at 24.4 A.P.M.	Fan			Boiler H. P. at 24.4 A.P.M.	Fan			Boiler H. P. at 24.4 A.P.M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
50	225	711	5440	2.36	250	795	6080	3.30	270	871	6660	4.34
60	320	592	7830	3.38	360	662	8750	4.72	395	725	9590	6.21
70	430	508	10670	4.61	490	568	11940	6.44	535	622	13070	6.63
80	570	443	13900	6.02	635	495	15540	8.41	700	543	17020	11.1
90	720	394	17600	7.63	805	441	19670	10.7	885	483	21550	14.0
100	890	355	21750	9.41	995	397	24320	13.2	1090	435	26640	17.3
110	1080	323	26290	11.4	1205	361	29390	15.9	1320	396	32200	21.0
120	1285	296	31310	13.6	1435	331	35000	19.0	1570	363	38350	25.0
130	1495	273	36500	15.9	1670	305	40800	22.2	1830	334	44700	29.2
140	1745	253	42600	18.4	1950	283	47630	25.7	2140	310	52170	33.8
150	2005	237	48880	21.0	2240	265	54640	29.4	2455	290	59860	38.6
160	2275	222	55500	24.0	2545	248	62050	33.6	2785	272	67970	44.1
170	2575	209	62800	27.2	2875	234	70200	38.0	3150	256	76910	50.0
180	2890	197	70500	30.5	3230	220	78810	42.6	3540	241	86340	56.0
190	3210	186	78270	33.9	3585	208	87500	47.3	3930	228	95860	62.3
200	3570	177	87050	37.6	3990	198	97330	52.5	4370	217	106600	69.1
210	3925	169	95770	41.4	4390	189	107100	57.8	4810	207	117300	76.0
220	4300	161	105020	45.5	4810	180	117400	63.6	5270	197	128600	83.7
230	4710	154	114900	49.7	5265	172	128500	69.4	5765	189	140700	91.2
240	5130	148	125160	54.2	5740	166	140000	75.7	6285	181	153300	99.6
250	5560	142	135620	58.7	6215	159	151600	82.0	6810	174	166100	107.8

INDUCED DRAFT FAN CAPACITIES
BUFFALO PLANOIDAL (TYPE L) EXHAUSTERS WITH ECONOMIZER

300°

Size of Fan	1¾ In. or 1.010 Oz. Static Press.				2 In. or 1.154 Oz. Static Press.				2½ In. or 1.442 Oz. Static Press.			
	Boiler H. P. at 24.4 A. P. M.	Fan			Boiler H. P. at 24.4 A. P. M.	Fan			Boiler H. P. at 24.4 A. P. M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
50	295	941	7200	5.46	315	1006	7690	6.68	350	1124	8600	9.33
60	425	783	10360	7.83	455	837	11070	9.56	505	936	12380	13.4
70	580	672	14120	10.7	620	718	15090	13.0	690	803	16870	18.2
80	755	586	18390	13.9	805	627	19660	17.0	900	701	21970	23.8
90	955	521	23290	17.7	1020	557	24890	21.6	1140	623	27830	30.2
100	1180	470	28780	21.8	1260	502	30760	26.6	1410	561	34390	37.2
110	1425	427	34780	26.4	1525	457	37180	32.3	1705	511	41560	45.1
120	1700	392	41420	31.5	1815	419	44280	38.5	2030	468	49500	53.8
130	1980	361	48290	36.8	2115	386	51620	45.0	2365	432	57700	62.9
140	2315	335	56620	42.6	2470	358	60240	52.1	2760	400	67350	72.7
150	2650	314	64670	48.7	2835	335	69120	59.5	3165	375	77280	83.1
160	3010	294	73430	55.6	3215	314	78480	68.0	3595	351	87740	95.0
170	3405	277	83080	63.0	3640	296	88800	76.9	4070	331	99280	107.5
180	3825	261	93270	70.6	4085	279	99700	86.2	4570	312	111500	120.4
190	4240	246	103500	78.5	4535	263	110700	95.8	5075	294	123800	133.9
200	4720	234	115200	87.0	5045	250	123100	106.3	5640	280	137600	148.6
210	5190	224	126700	95.7	5550	239	135400	117.0	6205	267	151400	163.5
220	5690	213	138900	105.4	6085	228	148500	128.8	6805	255	166000	180.0
230	6230	204	152000	115.0	6660	218	162500	140.4	7445	244	181700	196.3
240	6785	196	165600	125.5	7255	209	177000	153.3	8110	234	197900	214.2
250	7350	188	179400	135.8	7855	201	191700	166.0	8790	225	214400	231.9

INDUCED DRAFT FAN CAPACITIES
BUFFALO PLANOIDAL (TYPE L) EXHAUSTERS

550°

Size of Fan	½ In. or 0.288 Oz. Static Press.				¾ In. or 0.433 Oz. Static Press.				1 In. or 0.577 Oz. Static Press.			
	Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
50	135	580	4440	.96	170	711	5440	1.77	195	821	6280	2.72
60	195	483	6390	1.38	240	592	7830	2.54	280	683	9040	3.91
70	270	415	8710	1.89	330	508	10670	3.47	380	587	12320	5.33
80	350	362	11350	2.46	430	444	13900	4.53	495	512	16050	6.96
90	445	323	14380	3.12	545	395	17600	5.73	630	456	20330	8.81
100	550	290	17760	3.86	670	355	21760	7.06	775	410	25120	10.9
110	665	264	21470	4.67	810	323	26290	8.55	935	373	30360	13.2
120	790	242	25570	5.55	965	296	31320	10.2	1115	342	36160	15.7
130	920	223	29810	6.51	1125	273	36510	11.9	1300	315	42160	18.4
140	1075	207	34760	7.53	1315	254	42570	13.8	1515	293	49160	21.3
150	1230	193	39910	8.59	1505	237	48800	15.8	1740	273	56440	24.3
160	1400	182	45330	9.80	1700	223	55100	18.0	1980	257	64100	27.7
170	1585	171	51280	11.1	1940	210	62800	20.4	2240	242	72520	31.4
180	1775	161	57580	12.5	2175	198	70500	22.9	2525	228	81420	35.2
190	1975	152	63920	13.8	2415	186	78290	25.4	2790	215	90400	39.1
200	2195	144	71100	15.4	2685	177	87060	28.2	3105	204	100530	43.4
210	2415	138	78200	16.9	2955	169	95780	31.0	3415	195	110600	47.8
220	2650	132	85770	18.6	3240	161	105050	34.2	3745	186	121300	52.6
230	2895	126	93840	20.3	3550	154	114900	37.3	4095	178	132700	57.4
240	3155	121	102200	22.1	3865	148	125200	40.7	4460	171	144560	62.6
250	3420	116	110800	24.0	4185	142	135640	44.1	4835	164	156620	67.8

INDUCED DRAFT FAN CAPACITIES

BUFFALO PLANOIDAL (TYPE L) EXHAUSTERS

550°

Size of Fan	1¼ In. or 0.721 Oz. Static Press.				1½ In. or 0.865 Oz. Static Press.				2 In. or 1.154 Oz. Static Press.			
	Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
50	215	918	7020	3.80	235	1006	7690	5.00	270	1160	8880	7.69
60	310	764	10110	5.46	340	837	11070	7.18	395	966	12790	11.1
70	425	656	13770	7.45	465	719	15090	9.79	540	830	17430	15.1
80	555	572	17940	9.72	605	627	19660	12.8	700	724	22700	19.7
90	700	510	22730	12.3	770	559	24900	16.2	890	645	28750	24.9
100	865	458	28080	15.2	950	502	30760	20.0	1095	580	35530	30.7
110	1050	417	33940	18.4	1150	457	37180	24.2	1325	528	42940	37.2
120	1250	382	40420	22.0	1365	419	44290	28.9	1590	484	51440	44.5
130	1455	352	47130	25.6	1595	386	51630	33.7	1840	446	59630	51.9
140	1695	328	54960	29.7	1860	359	60200	39.1	2145	415	69530	60.1
150	1950	305	63110	34.0	2135	334	69120	44.7	2435	383	79820	68.7
160	2210	287	71660	38.8	2425	315	78500	51.0	2800	364	90660	78.5
170	2500	271	81070	43.9	2740	296	88810	57.7	3165	342	102600	88.8
180	2810	255	91000	49.2	3075	279	99710	64.7	3555	323	115200	99.6
190	3120	240	101100	54.6	3420	263	110800	71.9	3950	304	127900	110.6
200	3470	228	112400	60.6	3800	250	123100	79.7	4390	289	142200	122.8
210	3815	218	123600	66.7	4180	239	135500	87.7	4830	276	156400	135.1
220	4185	208	135600	73.5	4585	228	148600	96.6	5300	263	171600	148.7
230	4580	199	148300	80.1	5015	218	162500	105.3	5795	252	187700	162.2
240	4990	191	161600	87.4	5465	210	177000	115.0	6310	242	204500	177.0
250	5400	183	175100	94.7	5920	201	191800	124.5	6835	232	221500	191.7
260	5850	176	189500	102.4	6405	192	207500	134.6	7400	222	239700	207.3
270	6295	170	204000	110.4	6895	186	223400	145.1	7965	214	258000	223.5
280	6750	163	218700	118.5	7410	179	240000	155.8	8555	207	277100	239.8

INDUCED DRAFT FAN CAPACITIES
BUFFALO NIAGARA CONOIDAL (TYPE N) FANS

550°

Size of Fan	½ In. or 0.288 Oz. Static Press.				¾ In. or 0.433 Oz. Static Press.				1 In. or 0.577 Oz. Static Press.			
	Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
3	70	764	2290	.33	85	935	2810	.61	100	1080	3240	.94
3½	95	655	3120	.45	120	802	3820	.83	135	926	4410	1.28
4	125	573	4070	.59	155	702	4990	1.09	180	810	5760	1.67
4½	160	509	5160	.75	195	624	6310	1.38	225	720	7290	2.12
5	195	458	6360	.92	240	561	7800	1.70	275	648	9000	2.61
5½	240	417	7700	1.12	290	510	9430	2.06	335	589	10890	3.16
6	285	382	9160	1.33	345	468	11220	2.45	400	540	12960	3.76
7	385	327	12470	1.81	470	401	15280	3.33	545	463	17640	5.12
8	505	286	16290	2.37	615	351	19950	4.35	710	405	23040	6.69
9	635	255	20620	3.00	780	312	25250	5.51	900	360	29160	8.47
10	785	229	25450	3.70	960	281	31180	6.79	1110	324	36000	10.5
11	950	209	30800	4.47	1165	256	37730	8.22	1345	295	43560	12.7
12	1130	191	36650	5.32	1385	234	44900	9.78	1600	270	51840	15.1
13	1330	176	43020	6.25	1625	216	52690	11.5	1880	249	60840	17.7
14	1540	164	49890	7.24	1885	201	61100	13.3	2180	232	70560	20.5
15	1770	153	57270	8.31	2165	187	70150	15.3	2500	216	81000	23.5
16	2010	144	65160	9.46	2465	176	79800	17.4	2845	203	92150	26.8
17	2270	135	73540	10.7	2780	166	90100	19.6	3210	191	104000	30.2
18	2545	127	82450	12.0	3120	156	101000	22.0	3600	180	116600	33.9
19	2835	121	91920	13.4	3480	148	112600	24.5	4010	171	130000	37.7
20	3140	115	101800	14.8	3850	140	124700	27.2	4445	162	144000	41.8

INDUCED DRAFT FAN CAPACITIES
BUFFALO NIAGARA CONOIDAL (TYPE N) FANS

550°

Size of Fan	1¼ In. or 0.721 Oz. Static Press.				1½ In. or 0.865 Oz. Static Press.				2 In. or 1.154 Oz. Static Press.			
	Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan			Boiler H. P. at 32.4 A. P. M.	Fan		
		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.		R. P. M.	Vol.	H. P.
3	110	1208	3620	1.31	123	1322	3970	1.73	140	1527	4580	2.66
3½	150	1035	4930	1.79	165	1133	5400	2.35	195	1310	6240	3.62
4	200	906	6440	2.33	220	992	7050	3.07	250	1146	8150	4.72
4½	250	805	8150	2.96	275	881	8920	3.90	320	1018	10310	6.00
5	310	725	10060	3.65	340	793	11000	4.80	395	916	12730	[illegible]8
5½	375	659	12180	4.42	410	721	13330	5.81	475	833	15400	8.94
6	445	604	14490	5.25	490	661	15860	6.91	565	764	18330	10.6
7	610	518	19720	7.15	665	567	21600	9.41	770	655	24950	14.5
8	795	453	25760	9.35	870	496	28200	12.3	1005	573	32580	18.9
9	1000	403	32600	11.8	1100	441	35700	15.6	1275	509	41240	24.0
10	1245	362	40250	14.6	1360	397	44100	19.2	1570	458	50900	29.6
11	1505	330	48700	17.7	1645	361	53300	23.3	1900	417	61600	35.8
12	1790	302	57960	21.0	1960	331	63450	27.7	2260	382	73300	42.6
13	2100	279	68000	24.7	2300	305	74460	32.5	2655	352	86040	50.0
14	2435	259	78900	28.6	2665	284	86400	37.6	3080	328	99800	57.9
15	2795	242	90560	32.9	3060	264	99200	43.2	3535	306	114600	66.5
16	3180	227	103000	37.4	3490	249	113100	49.2	4015	287	130000	75.7
17	3590	214	116300	42.2	3930	234	127300	55.5	4540	270	147100	85.4
18	4020	201	130300	47.3	4405	220	142700	62.2	5090	255	164900	95.8
19	4485	191	145300	52.7	4910	209	159100	69.3	5680	242	183900	106.7
20	4970	181	161000	58.4	5440	198	176200	76.8	6285	229	203700	118.2

SPECIAL STEEL PLATE INDUCED DRAFT FANS
DIRECT CONNECTED TO BUFFALO HIGH SPEED CLASS "A" ENGINES

Combination Number	Engine Cylinder Diam. and Stroke	Steam Press. Gauge	Size of Fan	Diam. of Fan Inlet	Fan Outlet		Max. I. H. P. of Engine Frame	I. H. P. Required	Rev. per Min.	Cu. Ft. Gas per Min. at 550° F. and 1.69" Static Press.	Boiler H. P. Developed 50% Overload	Normal Boiler Rating
					Height of Outlet	Width of Fan						
1	4 x 4	55	90	27⅜	32	11	6	4.2	500	7260	225	150
2	4 x 4	76	90	30⅛	32	14½	6	5.7	500	9700	300	200
3	5 x 5	70	110	36⅝	39	17¾	12	8.5	415	14400	450	300
4	5 x 5	102	120	41⅜	42¾	21¾	12	11.7	385	19400	600	400
5	6 x 6	73	130	44	46¼	22½	20	13.2	355	21750	675	450
6	6 x 6	81	130	45¾	46¼	25¼	20	14.7	355	24200	750	500
7	7 x 7	66	150	50¼	53¼	24¼	20	16.0	300	27100	840	560
8	7 x 7	73	150	50¾	53¼	26¼	20	17.7	300	29100	900	600
9	6 x 8	95	160	53⅜	56¾	26½	45	18.8	290	31450	975	650
10	6 x 8	111	160	55⅞	56¾	30½	45	22.2	290	36100	1120	750
11	8 x 8	78	160	59⅝	56¾	37	45	27.6	290	43600	1350	900
12	8 x 8	89	160	61⅝	56¾	41	45	31.3	290	48400	1500	1000
13	8 x 8	104	160	64¼	56¾	46	45	36.8	290	54800	1700	1130
14	8 x 8	92	170	62⅞	60½	38½	45	30.6	273	48400	1500	1000
15	8 x 8	125	170	68⅜	60½	49¼	45	41.6	273	62000	1920	1280
16	10 x 8	67	160	64¼	56¾	46	45	36.8	290	54800	1700	1130
17	10 x 8	80	170	68⅜	60½	49¼	45	41.6	273	62000	1920	1280
18	10 x 8	75	180	68¼	64¼	43½	45	36.8	258	58200	1800	1200
19	10 x 8	77	190	69⅜	67½	41½	45	35.8	244	58200	1800	1200
20	8 x 10	94	180	68¼	64¼	43½	65	36.8	258	58200	1800	1200
21	8 x 10	96	190	69⅜	67½	41½	65	35.8	244	58200	1800	1200
22	8 x 10	127	190	74¾	67½	51¾	65	47.4	244	72700	2250	1500
23	10 x 10	89	190	76⅜	67½	55	65	52.0	244	77450	2400	1600
24	10 x 10	104	200	80½	71¼	57¾	65	57.7	232	86000	2660	1770
25	12 x 10	62	190	76⅜	67½	55	65	52.0	244	77450	2400	1600
26	12 x 10	73	200	80½	71¼	57¾	65	57.7	232	86000	2660	1770

SPECIAL STEEL PLATE INDUCED DRAFT FANS
DIRECT CONNECTED TO BUFFALO HIGH SPEED CLASS "A" ENGINES

Combination Number	Engine Cylinder Diam. and Stroke	Steam Press. Gauge	Size of Fan	Diam. of Fan Inlet	Fan Outlet		Max. I. H. P. of Engine Frame	I. H. P. Required	Rev. per Min.	Cu. Ft. Gas per Min. at 550° F. and 1.69" Static Press.	Boiler H. P. Developed 50% Overload	Normal Boiler Rating
					Height of Outlet	Width of Fan						
27	10 x 12	100	210	84¾	74⅝	60¾	95	63.5	220	94500	2920	1950
28	10 x 12	115	220	88¼	78	63¼	95	69.5	212	103800	3220	2150
29	12 x 12	80	220	88¼	78	63¼	95	69.5	212	103800	3220	2150
30	12 x 12	92	230	92½	81¾	66¼	95	76.0	202	113300	3510	2340
31	12 x 12	104	240	96½	85½	69¼	95	82.8	194	123500	3820	2540
32	13 x 12	68	220	88¼	78	63¼	95	69.5	212	103800	3220	2150
33	13 x 12	78	230	92½	81¾	66¼	95	76.0	202	113300	3510	2340
34	13 x 12	89	240	96½	85½	69¼	95	82.8	194	123500	3820	2540
35	12 x 14	101	250	100½	89	72	135	89.8	186	134000	4150	2760
36	12 x 14	113	260	104¼	92½	75	135	97.4	179	145000	4500	3000
37	14 x 14	95	270	109	96	77¾	135	106.5	172	159000	4925	3280
38	14 x 14	104	280	112¼	99½	80½	135	113.0	166	168000	5200	3470
39	15 x 14	91	280	112¼	99½	80½	200	113.0	166	168000	5200	3470
40	15 x 14	98	290	116½	103	83½	200	122.0	160	181000	5600	3730
41	15 x 14	112	300	120½	106½	86¼	200	130.0	155	193500	6000	4000
42	15 x 16	98	300	120½	106½	86¼	285	130.0	155	193500	6000	4000
43	15 x 16	108	310	124½	110	89¼	285	139.0	150	206500	6400	4260
44	16 x 16	95	310	124½	110	89¼	285	139.0	150	206500	6400	4260
45	16 x 16	104	320	128½	113½	92	285	147.0	145	219500	6800	4530
46	16 x 16	114	330	132½	117¼	95	285	157.0	141	233500	7220	4800
47	18 x 18	88	340	136½	121	98	350	167.0	137	248000	7700	5130
48	18 x 18	95	350	140½	124½	101	350	176.0	133	262000	8120	5400
49	18 x 18	104	360	145	128	103½	350	186.0	129	278000	8620	5750
50	18 x 18	113	370	148½	131½	106½	350	197.0	125	293500	9075	6050
51	20 x 18	92	370	148½	131½	106½	350	197.0	125	293500	9075	6050
52	20 x 18	100	380	152½	135	109¼	350	208.0	122	310000	9600	6400
53	20 x 18	106	390	157	138¼	112	350	219.0	119	327000	10100	6750
54	20 x 18	116	400	161	142½	115½	350	231.0	116	344000	10650	7100

SPECIAL STEEL PLATE INDUCED DRAFT FANS DIRECT CONNECTED TO BUFFALO HIGH SPEED ENGINES

Combination Number	Engine Cylinder Diam. and Stroke	Steam Press. Gauge	Size of Fan	Diam. of Fan Inlet	Fan Outlet		Rated I. H. P. of Engine	I. H. P. Required	Rev. per Min.	Cu. Ft. Gas per Min. at 550° F. and 1.69" Static Press.	Boiler H. P. Developed 50% Overload	Normal Boiler Rating
					Height of Outlet	Width of Fan						
Vertical—Class "I"—Cylinder Below Shaft												
55	3 x 3½	65	80	22½	28¼	8¼	5.0	2.8	580	4800	150	100
56	3 x 3½	100	80	26	28¼	12¼	5.0	4.5	580	7260	225	150
57	4 x 3½	85	80	28½	28¼	16½	7.5	6.4	580	9700	300	200
58	4½ x 5	75	110	34½	39	15	11.0	7.2	415	12100	375	250
59	4½ x 5	90	110	36½	39	17¾	11.0	8.8	415	14400	450	300
60	4½ x 5	105	110	38½	39	21	11.0	10.6	415	17000	525	350
61	5½ x 7	90	140	47¼	49¾	23½	18.5	14.9	325	24200	750	500
62	6½ x 8	80	160	52	56¾	24¾	25.0	17.8	290	29100	900	600
63	6½ x 8	100	160	56	56¾	30½	25.0	22.9	290	36100	1120	750
64	7½ x 9	85	180	61¾	64	32¾	30.0	27.2	260	43600	1350	900
65	7½ x 9	95	180	63	64	36¼	30.0	30.0	260	48400	1500	1000
Double Vertical—Double Acting												
66	3 x 3½	110	80	32½	28¼	24½	20.0	9.6	580	14400	450	300
67	4 x 3½	65	80	32½	28¼	24½	20.0	9.6	580	14400	450	300
68	4 x 4	85	90	38	32	29	20.0	12.9	500	19400	600	400
69	5 x 4	55	90	38	32	29	20.0	12.9	500	19400	600	400
70	6 x 5	55	110	46¼	39	35¾	35.0	19.5	415	29100	900	600
71	8 x 8	60	160	65½	56¾	48¼	60.0	38.7	290	58200	1800	1200

Planoidal Type "L" Fan Direct Connected to Double-Vertical, Double-Acting Engine

Double Turbo-Conoidal Type "T" Fan

BUFFALO CONE WHEELS

The cone wheel is a style of fan frequently used where the resistance to be overcome is moderate, or where it is merely required to exhaust the air from a chamber or to exhaust from a series of ducts into an attic or out of doors. It may be used in many cases where a disk fan is ordinarily installed, and will give better efficiency than the latter. The efficiency is, however, lower than that obtainable with a wheel enclosed in a housing, so that it is generally advisable to use a standard steel plate or multivane fan. This is especially true if it is necessary to operate against any considerable resistance.

The table on page 333 gives the cubic feet of air per revolution at free delivery, as well as the performance under various pressures. The air H. P. under free delivery may be calculated by H. P. $=0.00026 \times$ cap. $\times$ press. corresponding to the peripheral velocity expressed in inches. This should be increased to cover belt and bearing losses.

CAPACITIES OF BUFFALO CONE WHEELS UNDER AVERAGE WORKING CONDITIONS AT 70° F. AND 29.92 INCHES BAROMETER

Size	Cu. Ft. Air per Rev. at Free Delivery	¼" Static Press.			⅜" Static Press.			½" Static Press.			¾" Static Press.			1" Static Press.		
		R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
30	10	393	2300	.43	480	2810	.79	555	3250	1.21	680	3990	2.23	785	4600	3.43
36	17	328	3330	.62	400	4060	1.13	463	4700	1.75	568	5760	3.22	655	6650	4.95
42	27	282	4530	.85	343	5530	1.55	396	6390	2.39	486	7840	4.39	560	9050	6.75
48	40	246	5900	1.10	300	7210	2.02	347	8350	3.11	425	10220	5.72	491	11800	8.80
54	57	219	7480	1.39	266	9150	2.54	308	10550	3.92	378	12950	7.22	436	14950	11.1
60	78	197	9200	1.71	240	11250	3.14	278	13000	4.84	340	15950	8.90	393	18400	13.7
66	105	178	11150	2.10	218	13600	3.83	252	15750	5.90	309	19300	10.9	357	22300	16.7
72	136	164	13300	2.48	200	16250	4.54	232	18800	7.00	284	23050	12.9	328	26600	19.8
84	214	141	18100	3.38	172	22100	6.19	199	25500	9.55	244	31350	17.6	282	36200	27.0
96	322	123	23600	4.40	150	28800	8.07	174	33350	12.4	213	40900	22.9	246	47200	35.2
108	459	109	29950	5.58	133	36600	10.2	154	42250	15.8	189	51900	29.0	218	59900	44.6
120	631	98	36800	6.85	120	45000	12.6	138	52000	19.4	170	63800	35.6	196	73600	54.9
144	1085	82	53000	9.90	100	64850	18.1	116	75000	28.0	142	91850	51.5	164	106000	79.2
168	1730	71	72400	13.5	86	88450	24.8	100	102000	38.2	122	125200	70.2	141	144800	108.
180	2110	66	83250	15.5	80	101800	28.4	93	117500	43.9	114	144200	80.6	131	166500	124.

BUFFALO "B" VOLUME BLOWERS AND EXHAUSTERS (TYPES BB AND BE)

"B" Volume Blower

"B" Volume Exhauster

The table on page 335 shows the range of pressures and capacities for which these blowers and exhausters are designed, either for producing blast for forges and furnaces, for removing smoke and fumes in small ventilating installations, or for conveying dust and refuse from emery and polishing wheels. Data on application is given in another section. For forge blast a pressure of 3 to 5 ounces at the fan is sufficient, and for removing smoke a suction of 2 ounces at the fan is usually employed. For exhaust conveying systems either "B" volume exhausters or planing-mill exhaust fans may be used according to the nature of the material handled. With either type extra heavy blast wheel construction neutralizes the effect of abrasive material, while acid gases may be handled by blast wheels of cast iron, lead, copper, monel metal, or other suitable acid resisting material.

RATED CAPACITIES OF "B" VOLUME BLOWERS AND EXHAUSTERS (TYPES BB AND BE)

Total Pressure in Oz.

No. of Blower	½ Oz.			1 Oz.			1½ Oz.			2 Oz.		
	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.
1	1693	104	.02	2396	148	.07	2935	181	.14	3393	210	.23
2	1397	264	.06	1976	374	.19	2420	458	.34	2800	534	.59
3	980	438	.10	1387	621	.31	1695	760	.57	1965	888	.99
4	859	585	.13	1216	828	.41	1490	1015	.76	1724	1174	1.30
5	776	837	.19	1098	1185	.59	1345	1450	1.09	1556	1688	1.87
6	635	1185	.26	898	1677	.84	1100	2055	1.54	1274	2382	2.65
7	582	1372	.31	823	1941	.97	1010	2380	1.78	1168	2752	3.06
8	499	1986	.44	706	2810	1.41	865	3440	2.58	1000	3983	4.43
9	411	3299	.73	581	4668	2.33	710	5710	4.28	824	6641	7.30
10	349	4488	1.00	494	6350	3.18	605	7780	5.82	702	9003	9.90
	2½ Oz.			3 Oz.			4 Oz.			6 Oz.		
1	3795	234	.29	4169	258	.38						
2	3130	592	.75	3437	651	.96	3977	753	1.37			
3	2195	983	1.23	2414	1090	1.62	2794	1261	2.29	3436	1551	3.86
4	1925	1310	1.65	2119	1441	2.14	2452	1667	3.03	3015	2051	5.13
5	1740	1875	2.36	1912	2071	3.08	2212	2397	4.36	2721	2948	7.37
6	1425	2650	3.34	1563	2923	4.33	1809	3382	6.15	2225	4160	10.40
7	1300	3080	3.86	1434	3377	5.00	1660	3908	7.10	2041	4806	12.00
8	1120	4450	5.60	1229	4888	7.24	1422	5656	10.20	1748	6957	17.40
9	920	7400	9.28	1012	8150	12.10	1171	9431	17.10	1440	11599	28.90
10	782	10050	12.60	861	11050	15.00	966	12786	21.90	1225	15726	37.00

BUFFALO STEEL PRESSURE BLOWERS
(TYPE P)

Steel Pressure Blowers are designed for relatively higher pressures and smaller capacities than "B" Volume Blowers and while they may be used for the same purposes, are intended especially for supplying blast to cupolas, furnaces, and forges requiring air pressure of from 6 to 14 ounces per square inch.

Steel Pressure Blowers for pressures as high as 16 ounces are also built in two stages.

The table on page 337 gives capacities and horsepower required for these blowers at various speeds and pressures. Table on page 110 gives special information regarding requirements for foundry service, and table on page 338 describes method of choosing blower and laying out piping in forge shops.

CAPACITIES OF BUFFALO STEEL PRESSURE BLOWERS (TYPE P) UNDER ORDINARY WORKING CONDITIONS TEMPERATURE 70° F. AND 29.92 INCHES BAROMETER

Static Pressure in Ounces

No. of Blower	4 Oz.			5 Oz.			6 Oz.			7 Oz.			8 Oz.		
	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.
3	3950	565	1.25	4435	635	1.75									
4	3330	600	1.32	3730	670	1.85	4065	730	2.40	4395	785	3.05			
5	2930	670	1.47	3290	755	2.06	3585	825	2.70	3870	890	3.38	4130	950	4.14
6	2550	880	1.94	2860	985	2.70	3115	1076	3.52	3360	1160	4.42	3585	1240	5.42
7	2255	1045	2.27	2535	1170	3.32	2765	1275	4.15	2985	1375	5.25	3180	1470	6.40
8	2050	1570	3.43	2300	1765	4.80	2510	1925	6.28	2710	2080	7.93	2890	2220	9.66
9	1840	2225	4.84	2060	2500	6.80	2245	2720	8.87	2425	2940	11.2	2585	3135	13.7
10	1375	3255	7.09	1540	3655	9.93	1680	3990	13.0	1815	4305	16.4	1935	4590	20.0
11	1145	4010	8.74	1285	4515	12.3	1400	4915	16.1	1510	5300	20.3	1615	5660	24.7
11½	907	4500	10.1	1020	5040	14.1	1110	5500	18.5	1200	5940	23.4	1280	6350	28.5
12	930	5210	11.3	1045	5840	15.9	1135	6380	20.8	1230	6880	26.3	1310	7350	32.0

No. of Blower	9 Oz.			10 Oz.			12 Oz.			14 Oz.			16 Oz.		
	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.	R.P.M.	Cap.	H. P.
5	4375	960	4.95												
6	3810	1310	6.45	4000	1385	7.55	4380	1510	9.90						
7	3375	1555	7.61	3560	1640	8.90	3880	1790	11.7	4195	1930	14.7			
8	3065	2350	11.6	3225	2480	13.6	3525	2705	17.6	3810	2920	22.3	4060	3115	27.1
9	2740	3320	16.3	2890	3500	19.0	3155	3825	25.0	3410	4125	31.4	3635	4400	38.3
10	2050	4870	23.8	2160	5135	27.9	2360	5595	36.5	2545	6040	46.1	2720	6510	56.7
11	1710	5995	29.4	1800	6320	34.4	1970	6900	45.0	2120	7455	56.7	2265	7940	69.1
11½	1355	6700	33.8	1425	7150	40.2	1555	7720	52.0	1680	8340	65.5	1795	8960	80.5
12	1390	7780	38.1	1460	8200	44.6	1595	8955	58.4	1720	9660	73.5	1840	10395	90.5

BUFFALO STEEL PRESSURE BLOWERS (TYPE P)
APPLICATION TO FORGE FIRES

Static Pressure in Ounces

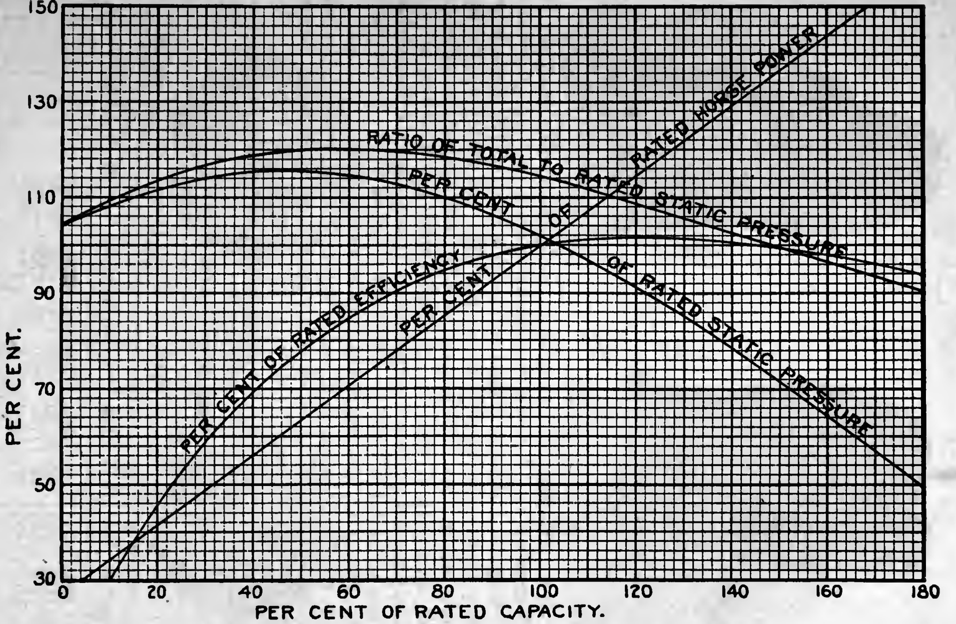
How Many Forges	Use Blower No.	Diam. of Main Blast-Pipe	4 oz. Pressure		5 oz. Pressure		6 oz. Pressure		8 oz. Pressure	
			Speed	H. P.	Speed	H. P.	Speed	H. P.	Speed	H. P.
2	2	4½	4986	.79	5596	1.01				
4	3	5	3993	1.47	4473	1.63	4811	2.45		
6	4	5½	3363	1.56	3754	1.80	4051	2.60		
8	5	6	2952	1.78	3308	1.96	3564	2.95	4107	4.39
10	6	7	2573	1.95	2883	2.53	3104	3.31	3577	4.93
13	7	8	2275	2.23	2549	3.02	2749	4.28	3168	6.60
18	8	9½	2067	3.25	2316	4.53	2499	6.46	2880	9.76
26	9	10½	1851	4.75	2074	6.45	2238	9.03	2579	13.66
38	10	12½	1384	6.75	1550	9.41	1673	12.91	1928	19.65
50	11	15	1154	8.50	1293	11.60	1394	15.77	1608	24.11

For a number of average fires not exceeding a total of ten, four ounces pressure at the blower is sufficient. If length of main blast-pipe is over 100 feet use next larger size pipe than shown in above table for the blower chosen. If length of main blast-pipe is over 150 feet increase pipe two sizes. Branch pipes to each forge should be three inches in diameter. Increasing size of pipes reduces friction, increases pressures at the fires, allows speed of blower to be reduced and saves power. If fires are extra heavy run the blower at a higher speed than shown in above table, if necessary, to get satisfactory results.

For 12 or more average fires five ounces pressure at the blower is necessary. If main blast-pipe is over 100 feet long, increase size as described above.

In railroad, implement and similar shops where some or all of the fires are large and deep it is necessary to maintain six or eight ounces pressure at the blower, depending on the number of fires.

As the outlet of the blower is smaller than the pipe recommended use an increaser to connect them.



Performance Curve of Buffalo Standard Steel Pressure Blowers

BUFFALO STEEL PLATE PRESSURE BLOWERS (TYPE R)

Pulley Driven

Motor Driven

These are high efficiency fans, and are usually designed for pressures up to 14 or 16 ounces for cupola or furnace service, but may be built for pressures up to two or three pounds per square inch. The speeds for cupola work are suitable for direct connected motors, which are usually mounted on a sub-base built as a part of the fan. In large units the bearings are frequently mounted on independent pedestals, and the fans driven through flexible couplings, while for smaller sizes the fan wheel is overhung on the extended motor shaft.

It is possible to obtain, with a fan of this type, higher efficiencies than with standard radial blade steel plate fans, or with any form of multiblade fan.

CAPACITIES OF BUFFALO STEEL PLATE PRESSURE BLOWERS

No. of Blower	Static Pressure in Oz. per Sq. In.											
	10 Oz.			12 Oz.			14 Oz.			16 Oz.		
	R.P.M.	Vol.	H.P.	R.P.M.	Vol.	H.P.	R.P.M.	Vol.	H.P.	R.P.M.	Vol.	H.P.
5	1700	2700	13	1700	2700	16	1700	2700				
6	1700	3600	18	1700	3600	21	1700	3600				
7	1700	4800	24	1700	4800	29	1700	4800				
8	1700	6400	32	1700	6400	38	1700	6400				
9				1120	8000	48	1120	8000	55	1120	8000	63
10				1120	10000	58	1120	10000	69	1120	10000	79
11				860	12000	71	860	12000	83	860	12000	95
12				860	15000	89	860	15000	104	860	15000	119

BUFFALO STANDARD REVERSIBLE PLANING-MILL EXHAUSTERS (TYPE M)

Pulley Driven

Motor Driven

Standard Blast-Wheel for Buffalo Steel Plate Mill Exhauster

Blast-Wheel for Stringy Material

BUFFALO STANDARD PLANING-MILL EXHAUSTERS (TYPE M)

These fans are ordinarily used for conveying materials and for removing shavings and factory refuse in general. Instructions for application are given in another section. The construction is similar to steel plate ventilating fans, but with special proportions and of considerably heavier material to stand wear. The fan wheels are always overhung, and the bearings of extra size. These fans are made single and double. The table below gives speed, capacity and horsepower for various pressures for single fans.

CAPACITIES UNDER NORMAL WORKING CONDITIONS

Total Pressure in Ounces

Size	1 Oz.			2 Oz.			3 Oz.		
	R.P.M.	Cap.	H.P.	R.P.M.	Cap.	H.P.	R.P.M.	Cap.	H.P.
30	1025	1650	.90	1450	2340	2.55	1775	2850	4.65
35	890	2300	1.25	1260	3250	3.53	1540	3975	6.48
40	770	3000	1.63	1090	4250	4.60	1334	5190	8.40
45	690	3825	2.08	976	5410	5.95	1195	6620	10.78
50	622	4750	2.58	880	6720	7.28	1078	8220	13.38
55	570	5750	3.12	806	8120	8.83	987	9950	16.25
60	520	6900	3.75	735	9750	10.60	900	11950	19.50
70	450	9400	5.10	637	13300	14.50	780	16300	26.60
80	390	12200	6.63	552	17280	18.75	676	21200	34.50

Size	4 Oz.			5 Oz.			6 Oz.		
	R.P.M.	Cap.	H.P.	R.P.M.	Cap.	H.P.	R.P.M.	Cap.	H.P.
30	2050	3300	7.20	2290	3680	10.05	2510	4040	13.32
35	1780	4600	10.00	1990	5140	13.92	2180	5630	18.35
40	1540	6000	13.00	1722	6700	18.15	1888	7350	23.85
45	1380	7650	16.60	1542	8550	23.20	1690	9350	30.40
50	1245	9500	20.60	1391	10600	28.80	1525	11620	37.90
55	1140	11500	25.00	1275	12850	34.90	1398	14080	45.80
60	1040	13800	30.00	1162	15400	41.90	1273	16900	55.00
70	900	18800	40.90	1005	21000	56.90	1100	23000	75.00
80	780	24400	53.00	872	27300	74.00	956	29850	97.20

NOTE—To make connections for special operating conditions use table on page 343.

BUFFALO SINGLE STANDARD PLANING-MILL EXHAUSTERS (TYPE M) WITH DIFFERENT AREA SUCTION PIPES AND VARYING VELOCITIES

Speed and Power Requirements

Exhauster			Suction Branches		Velocity Through Branch Suction Pipes in Feet per Minute											
	Inlet and Outlet				3000			3500			4000			4500		
Size	Diameter	Area Sq. In.	Area Sq. In.	Equivalent Diameter	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.
30	12	113	79	10	1635	1410	2.0	1910	1675	3.3	2180	1925	4.72	2450	2140	6.6
			113	12	2360	1620	3.2	2750	1890	5.1	3150	2170	7.60	3540	1485	10.8
			154	14	3190	1940	5.6	3720	2240	9.2	4250	2552	13.50			
35	14	154	113	12	2360	1185	2.52	2750	1390	4.02	3150	1570	6.00	3540	1775	8.4
			154	14	3190	1350	3.90	3720	1570	6.25	4250	1780	9.35	4790	1990	13.1
			201	16	4200	1535	6.35	4890	1775	10.00	5540	2020	14.60	6280	1470	23.3
40	16	201	154	14	3190	1018	3.12	3720	1185	5.0	4250	1350	7.4	4790	1520	10.6
			201	16	4200	1120	4.70	4890	1320	7.7	5540	1495	11.3	6280	1755	16.2
			254	18	5310	1295	7.58	6200	1530	12.4	7080	1730	18.1	7980	1970	25.8
45	18	254	201	16	4200	908	3.90	4890	1030	6.25	5540	1170	9.25	6280	1320	13.1
			254	18	5310	973	5.65	6200	1140	9.10	7080	1295	13.30	7980	1458	19.2
			314	20	6550	1090	8.40	7650	1370	13.40	8730	1450	19.20	9820	1640	28.2
50	20	314	254	18	5310	770	4.7	6200	905	7.45	7080	1028	11.0	7980	1160	15.85
			314	20	6550	863	6.6	7650	991	10.70	8730	1130	15.7	9820	1270	22.30
			380	22	7920	942	9.5	9250	1110	15.20	10570	1260	22.2	11890	1410	31.80
55	22	380	314	20	6550	690	5.50	7650	810	8.8	8730	908	12.6	9820	1040	18.7
			380	22	7920	748	7.58	9250	878	12.5	10570	991	17.6	11890	1105	25.4
			452	24	9450	840	10.60	11000	990	17.2	12550	1105	24.7	14150	1265	35.5
60	24	452	380	22	7920	630	6.42	9250	718	9.75	10570	832	15.3	11890	940	21.5
			452	24	9450	684	8.60	11000	808	13.80	12550	911	20.4	14150	1045	28.1
			531	26	11100	738	11.10	12900	862	18.90	14700	955	24.6	16500	1100	38.0
70	28	616	531	26	11100	530	8.3	12900	622	13.4	14700	704	19.4	16500	795	27.8
			616	28	12800	575	11.0	14950	670	18.3	17100	744	25.8	19200	858	36.6
			707	30	14700	620	14.3	17100	720	22.6	19600	820	33.2	22100	920	47.4
80	32	804	707	30	14700	460	10.5	17100	535	16.8	19600	607	24.9	22100	690	35.6
			804	32	16700	485	13.2	19500	569	22.6	22200	645	31.2	25000	730	48.0
			908	34	18900	521	16.8	22100	611	26.7	25200	696	40.0	28300	789	57.5

Note—Tables are computed on the basis that the system will have 275 feet of piping including equivalent of one collector. The diameter of main discharge pipe is in each instance assumed of same area as the fan outlet. For each additional 10 feet of suction or discharge piping, the speed should be increased approximately one per cent. and the power will be increased approximately three per cent. If a collector and elbows are included in the system, the length of pipe to which they are equivalent must be added to the actual length, in order to determine the total equivalent operating length from which speed and power may be figured. If the total operating length is less than 275 feet, the speed should be decreased approximately one per cent. for each 10 feet and the power will be decreased approximately three per cent. For double fans, power and air handled will be doubled.

BUFFALO SLOW SPEED REVERSIBLE PLANING-MILL EXHAUSTERS (TYPE E)

Suction Side

Bearing Side

Standard Slow Speed, High Efficiency Blast-Wheel

Slow Speed Blast-Wheel for Stringy Material

BUFFALO SLOW SPEED PLANING-MILL EXHAUSTERS (TYPE E)

These fans are of the high efficiency type explained elsewhere, and while intended for the same purposes as the standard mill exhausters, require from 15 to 50 per cent. less power. The speed is also reduced one-third, and the size of the fan is increased nearly 50 per cent. For cases where refuse fuel is not available for furnishing power, it is advisable to use this fan, on account of the decrease in power cost.

CAPACITIES UNDER NORMAL WORKING CONDITIONS

Total Pressure in Ounces

Size	1 Oz.			2 Oz.			3 Oz.		
	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.
30	640	1650	.75	906	2340	2.12	1110	2850	3.87
35	552	2300	1.04	781	3250	2.94	958	3975	5.40
40	482	3000	1.36	682	4250	3.83	837	5190	7.00
45	428	3825	1.73	605	5410	4.96	742	6620	8.97
50	385	4750	2.15	544	6720	6.06	667	8220	11.10
55	350	5750	2.60	494	8120	7.35	606	9950	13.50
60	321	6900	3.12	453	9750	8.83	556	11950	16.20
70	275	9400	4.25	387	13300	12.10	477	16300	22.10
80	241	12200	5.52	341	17280	15.60	418	21200	28.70

Size	4 Oz.			5 Oz.			6 Oz.		
	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.	R. P. M.	Cap.	H. P.
30	1280	3300	6.00	1428	3680	8.37	1570	4040	11.10
35	1100	4600	8.32	1230	5140	11.59	1350	5630	15.25
40	965	6000	10.80	1075	6700	15.10	1180	7350	19.84
45	855	7650	13.80	955	8550	19.3	1050	9350	25.30
50	769	9500	17.12	860	10600	24.0	942	11620	31.50
55	698	11500	20.80	782	12850	29.1	856	14080	38.10
60	641	13800	25.00	718	15400	34.7	786	16900	45.80
70	550	18800	34.10	613	21000	47.3	674	23000	62.40
80	482	24400	44.20	570	27300	61.7	590	29850	81.00

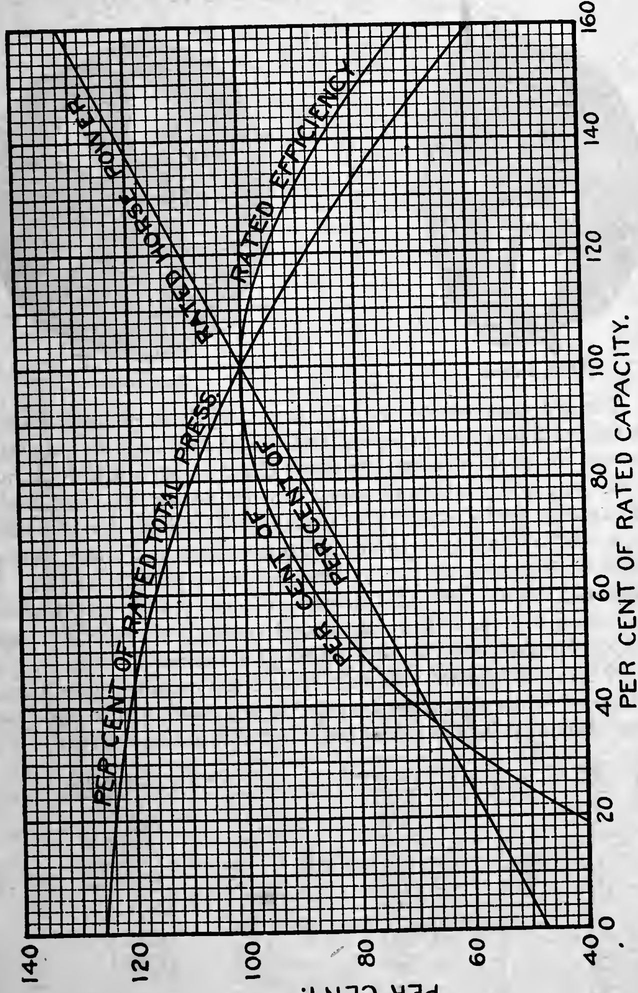
NOTE—To make connections for special operating conditions use table on page 346.

BUFFALO SINGLE SLOW SPEED HIGH EFFICIENCY MILL EXHAUSTERS (TYPE E) WITH DIFFERENT AREA SUCTION PIPES AND VARYING VELOCITIES

Speed and Power Requirements

Exhauster					Suction Branches		Velocity Through Branch Suction Pipes in Feet per Min.											
	Inlet		Outlet				3000			3500			4000			4500		
Size	Diameter	Area Sq. In.	Size	Area Sq. In.	Area Sq. in.	Equivalent Diameter	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.	Cubic Feet per Minute	R. P. M.	Brake H. P.
30	12½	123	11¾x9⅞	116	79	10	1635	863	1.6	1910	1022	2.7	2180	1175	3.9	2450	1300	5.5
					113	12	2360	989	2.6	2750	1155	4.2	3150	1319	6.3	3540	1485	9.0
					154	14	3190	1171	4.6	3720	1365	7.6	4250	1552	11.2			
35	14⅝	168	13⅝x11½	157	113	12	2360	724	2.1	2750	850	3.3	3150	970	5.0	3540	1081	7.0
					154	14	3190	822	3.2	3720	955	5.2	4250	1083	7.8	4790	1215	10.9
					201	16	4200	935	5.3	4890	1082	8.3	5540	1233	12.2	6280	1470	19.4
40	16⅝	217	15⅝x13⅛	206	154	14	3190	620	2.6	3720	721	4.1	4250	824	6.1	4790	927	8.8
					201	16	4200	683	3.9	4890	806	6.4	5540	911	9.4	6280	1070	13.5
					254	18	5310	790	6.3	6200	936	10.3	7080	1055	15.1	7980	1200	21.5
45	18⅝	272	17⅝x14⅝	258	201	16	4200	553	3.2	4890	629	5.2	5540	714	7.7	6280	807	10.9
					254	18	5310	593	4.7	6200	695	7.6	7080	790	11.1	7980	889	16.0
					314	20	6550	664	7.0	7650	777	11.1	8730	888	16.0	9820	1000	23.5
50	20⅝	334	19¼x16⅝	320	254	18	5310	470	3.9	6200	551	6.2	7080	627	9.2	7980	706	13.2
					314	20	6550	526	5.5	7650	606	8.9	8730	690	13.1	9820	775	18.6
					380	22	7920	575	7.9	9250	678	12.6	10570	770	18.5	11890	862	26.5
55	22¾	406	21⅜x18⅛	387	314	20	6550	422	4.6	7650	494	7.3	8730	553	10.5	9820	634	15.6
					380	22	7920	456	6.3	9250	534	10.2	10570	606	14.7	11890	674	21.2
					452	24	9450	512	8.8	11000	606	14.2	12550	672	20.5	14150	772	29.6
60	24¾	481	23⅛x19⅞	460	380	22	7920	384	5.3	9250	437	8.1	10570	509	12.7	11890	573	17.9
					452	24	9450	417	7.1	11000	491	11.5	12550	556	16.9	14150	637	23.4
					531	26	11100	450	9.3	12900	526	14.9	14700	582	20.5	16500	678	31.6
70	28¾	649	27x23	621	531	26	11100	323	6.9	12900	380	11.1	14700	429	16.2	16500	484	23.2
					616	28	12800	351	9.2	14950	408	15.3	17100	454	21.5	19200	522	30.5
					707	30	14700	378	11.9	17100	440	18.8	19600	500	27.7	22100	561	39.5
80	32¾	842	30¼x26⅝	804	707	30	14700	280	8.8	17100	327	14.0	19600	370	20.7	22100	421	29.7
					804	32	16700	296	11.0	19500	347	18.8	22200	394	26.0	25000	446	40.0
					908	34	18900	319	14.0	22100	374	22.2	25200	425	33.5	28300	481	48.0

Note—Tables are computed on the basis that the system will have 275 feet of piping including equivalent of one collector. The diameter of main discharge pipe is in each instance assumed of same area as the fan outlet. For each additional 10 feet of suction or discharge piping, the speed should be increased approximately one per cent. and the power will be increased approximately three per cent. If a collector and elbows are included in the system, the length of pipe to which they are equivalent must be added to the actual length, in order to determine the total equivalent operating length from which speed and power may be figured. If the total operating length is less than 275 feet, the speed should be decreased approximately one per cent. for each 10 feet and the power will be decreased approximately three per cent. For double fans, power and air handled will be doubled.



Performance Curve of Buffalo Slow Speed Planing-Mill Exhausters

BUFFALO DISK FANS (TYPE D)

Pulley Driven

Motor Driven

The ordinary disk or propeller fans should not be used in connection with a system of piping, but should discharge directly into a room, or exhaust from it without obstruction. Although not as efficient as a centrifugal cased fan, the lower first cost, large air capacity and simplicity of installation account for the wide use of fans of this type for ventilating engine and boiler rooms, kitchens, restaurants, small theatres, brass foundries, etc. A conservative table for the air capacities of actual disk fan installations is given below for normal speeds, and table on page 349 gives capacities and horsepowers for various speeds.

These disk fans are probably more often installed with direct connected motors than for belt drive, and such outfits have become standardized for both direct and alternating current.

Size	Normal Speed	Cu. Ft. Air per Min.
18	1060	2050
24	800	3725
30	660	5950
36	530	8240
42	450	11150
48	400	14600
54	350	18450
60	320	22900
72	265	32850
84	230	44800
96	200	58700
108	175	74300

PERFORMANCE OF BUFFALO DISK WHEELS (TYPE D) OPERATING AT FREE DELIVERY—ANGLE OF BLADES 30°

Peri. Velocity	3000			4000			5000			6000			7000		
Size	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
18	636	1230	.019	850	1650	.046	1060	2050	.089	1274	2480	.155	1486	2880	.247
24	477	2230	.062	638	2990	.148	796	3720	.286	956	4470	.498	1115	5210	.795
30	398	3580	.109	531	4780	.259	663	5970	.526	796	7160	.876	929	8360	1.410
36	318	4940	.137	425	6590	.328	530	8240	.630	637	9900	1.100	743	11520	1.780
42	273	6730	.189	364	8970	.484	454	11160	.870	546	13410	1.520	637	15660	2.410
48	239	8790	.249	319	11700	.592	398	14580	1.150	478	17550	2.000	557	20520	3.150
54	212	11070	.307	283	14850	.744	353	18450	1.450	425	22230	2.570	495	25920	3.980
60	191	13680	.388	255	18360	.972	318	22860	1.890	382	27450	3.220	446	32040	4.940
72	159	19700	.556	213	26550	1.340	265	32850	2.580	319	39600	4.490	372	46260	7.120
84	136	26800	.750	182	35900	1.800	227	44800	3.550	273	53900	6.060	318	62800	9.660
96	119	35000	.978	159	46900	2.350	199	58700	4.600	226	66600	7.740	279	82300	12.660
108	106	44500	1.250	142	59600	3.020	177	74300	5.830	212	89000	10.000	248	103500	16.620

Note—Air Velocity = 16.2% of Peripheral Velocity

BUFFALO MULTIBLADE DISK FANS (TYPE CM)

Disk fans with many overlapping blades are better suited than standard disk fans for maintaining sufficient pressure to overcome a moderate piping resistance or other friction, and are usually employed for boosters, in mine ventilation, or for producing air flow in cooling towers for condensing plants. The casing and bearings are self-contained to facilitate installation. The normal speeds, air capacities and horsepowers are given in the following table:

Size	Normal Speed	Cu. Ft. Air per Min.	Horsepower
18	900	3200	.25
24	800	6300	.50
30	650	10000	.75
36	525	14000	1.00
42	450	19300	1.50
48	400	25200	2.00
54	350	32000	2.50
60	320	36000	3.00
72	265	56000	5.00
84	226	77000	7.50

BUFFALO PROPELLER FANS (TYPE F)

Pulley Driven

Motor Driven

The propeller fan has a capacity 25 to 30 per cent. greater than a disk fan of the same size, is used for the same general purposes, and may be furnished either pulley driven or with direct connected motor. 48-inch and smaller disk and propeller fans are made with overhung wheels, so that it is unnecessary to reach between the blades for oiling the outer bearing.

Table of capacities and horsepowers at normal speed is given below.

Size	Normal Speed	Cu. Ft. Air per Min.	Horsepower	Pulley Size
18	1050	2600	.14	2 x 4
24	800	4750	.37	2 x 4
30	650	7600	.79	2⅜ x 6
36	525	10500	.95	3 x 7
42	450	14250	1.30	3½ x 8
48	400	18650	1.75	4 x 9
54	350	23550	2.20	4 x 9
60	320	29200	2.85	5 x 10
72	265	42000	3.90	5½ x 12
84	225	57000	5.30	6 x 14

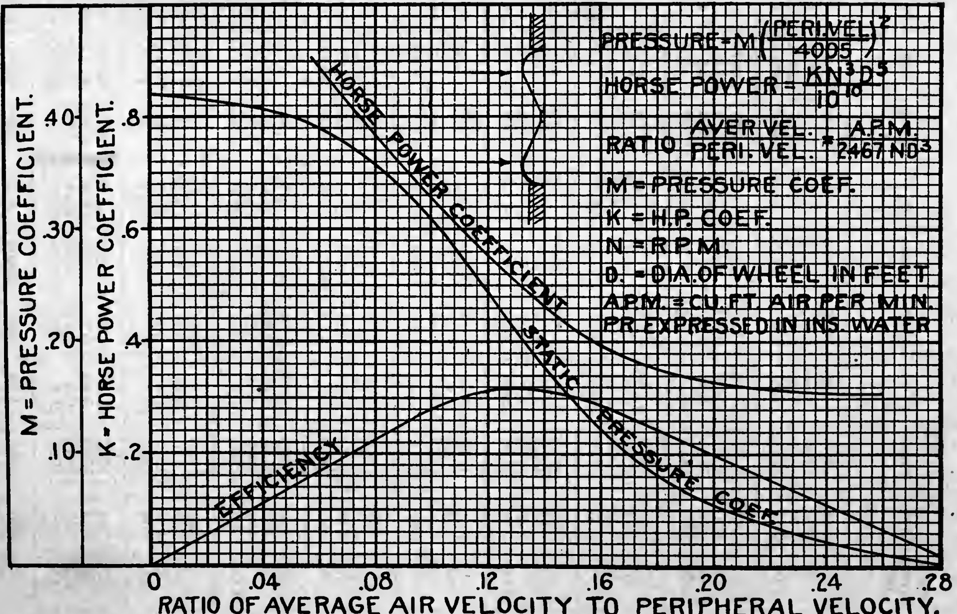
PERFORMANCE OF BUFFALO PROPELLER WHEELS (TYPE F) OPERATING AT FREE DELIVERY—ANGLE OF BLADES 30°

Peri. Velocity	3000			4000			5000			6000			7000		
Size	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
18	636	1580	.029	850	2110	.069	1060	2620	.134	1274	3160	.233	1486	3680	.371
24	477	2850	.093	638	3820	.232	796	4750	.369	956	5720	.747	1115	6660	1.19
30	398	4580	.164	531	6110	.389	663	7630	.789	796	9160	1.31	929	10690	2.12
36	318	6310	.206	425	8420	.492	530	10520	.945	637	12650	1.65	743	14720	2.67
42	273	8600	.284	364	11470	.726	454	14260	1.31	546	17140	2.28	637	20000	3.62
48	239	10100	.374	319	14950	.888	398	18630	1.73	478	22430	3.00	557	26220	4.73
54	212	14150	.461	283	18980	1.12	353	23580	2.18	425	28410	3.86	495	33130	5.97
60	191	17480	.582	255	23460	1.46	318	29210	2.84	382	35080	4.83	446	40950	7.41
72	159	25200	.834	213	33930	2.01	265	41980	3.87	319	50610	6.74	372	59100	10.68
84	136	34280	1.13	182	45900	2.70	227	57300	5.33	273	68900	9.09	318	80300	14.49
96	119	44740	1.47	159	59900	3.53	199	75000	6.90	226	86000	11.61	279	105000	18.99
108	106	56800	1.88	142	76100	4.53	177	94900	8.75	212	113800	15.00	248	132300	24.93

NOTE—Air Velocity = 20.7% of Peripheral Velocity

PERFORMANCE OF 8-BLADE PROPELLER WHEELS—30° ANGLE OPERATING AGAINST RESISTANCE

Size	Static Press. In.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.	R.P.M.	Vol.	H. P.
18″	.25	774	690	.20	954	1140	.31	1240	2070	.52
	.50	1094	970	.55	1346	1610	.86	1754	2920	1.46
	.75	1340	1190	1.02	1654	1980	1.59	2146	3570	2.70
	1.00	1546	1370	1.57	1906	2280	2.44	2480	4130	4.13
24″	.25	580	1220	.35	715	2025	.54	930	3760	.92
	.50	820	1725	.99	1010	2860	1.53	1315	5190	2.59
	.75	1005	2115	1.81	1240	3510	2.82	1610	6350	4.76
	1.00	1160	2440	2.79	1430	4050	4.34	1860	7340	7.34
30″	.25	464	1910	.55	572	3160	.85	744	5730	1.43
	.50	653	2690	1.54	809	4470	2.39	1050	8100	4.04
	.75	804	3300	2.84	990	5480	4.40	1289	9930	7.43
	1.00	928	3810	4.36	1143	6320	6.76	1488	11450	11.4
36″	.25	387	2750	.79	477	4560	1.22	620	8260	2.07
	.50	547	3880	2.22	673	6430	3.44	877	11680	5.83
	.75	670	4760	4.07	827	7900	6.35	1073	14290	10.7
	1.00	773	5490	6.28	953	9110	9.76	1240	16520	16.5
42″	.25	331	3740	1.07	409	6200	1.65	531	11240	2.81
	.50	469	5280	3.03	577	8760	4.69	751	15890	7.93
	.75	574	6480	5.54	709	10750	8.64	920	19450	14.6
	1.00	663	7470	8.54	817	12400	13.3	1063	22480	22.5
48	.25	290	4880	1.40	358	8100	2.16	465	14680	3.68
	.50	410	6900	3.96	505	11440	6.12	658	20760	10.4
	.75	503	8460	7.24	620	14040	11.3	805	25400	19.0
	1.00	580	9760	11.2	715	16200	17.4	930	29360	29.4
54″	.25	268	6200	1.77	318	10250	2.74	414	19050	4.66
	.50	364	8750	5.02	450	14500	7.75	585	26300	13.1
	.75	448	10700	9.18	552	17800	14.3	716	32200	24.1
	1.00	516	12350	14.1	636	20500	22.0	828	37200	37.2
60″	.25	232	7630	2.19	286	12600	3.38	372	22940	5.75
	.50	327	10780	6.19	405	17880	9.56	525	32440	16.2
	.75	402	13220	11.3	495	21940	17.6	645	39690	29.8
	1.00	464	15250	17.4	572	25310	27.1	744	45880	45.9
72″	.25	194	11000	3.16	239	18240	4.88	310	33040	8.28
	.50	274	15520	8.88	337	25720	13.8	439	46720	23.3
	.75	335	19040	16.3	414	31600	25.4	537	57160	42.8
	1.00	387	21960	25.1	477	36440	39.0	620	66080	66.0
84″	.25	166	14960	4.28	205	24800	6.60	266	44960	11.2
	.50	235	21120	12.1	289	35040	18.8	376	63560	31.7
	.75	287	25920	22.2	355	43000	34.6	460	77800	58.4
	1.00	332	29880	34.2	409	49600	53.2	532	89920	90.0



Performance Curve of Buffalo 8-Blade Propeller Wheel— 30° Angle

BUFFALO ELECTRIC BLOWERS (TYPE FB)

Constant Speed

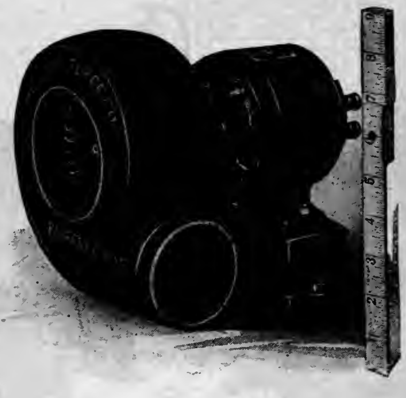
Variable Speed

This type of blower has been developed for furnishing small volumes of air at pressures from one to three ounces for forge fires and furnaces, for blowing church organs, and in fact any purpose for which the various sizes may be applicable, handling from 60 to 250 cu. ft. per minute.

These fans may be used for exhausting at the same pressures, and are furnished with motors for 110 or 220 volts, either alternating or direct current. The design of the blast-wheel and casing is special, similar to the high efficiency steel plate fans, so as to make the power consumption remarkably low.

No. of Blower	R. P. M.	Cu. Ft. Air per Min.	Pressure Oz. per Sq. In.	Diam. of Outlet	Total Height
1E	3800	60	1	3″	10″
2E	1800	75	1½	3″	15″
2EH	3000	150	2½	3″	15″
3E	3000	200	2	4″	15″
4E	3200	250	2½	5″	20″

BABY CONOIDAL FANS (TYPE IC)



Small motor driven fans for exhaust ventilation are preferable to the use of desk fans, since they provide means for introducing fresh air, or for positively removing fumes and odors. They are also used for small drying outfits in connection with steam or electrical heaters. Standard sizes are arranged for direct or alternating current motors; fans are of Conoidal type with housings which are reversible. The following table shows capacities of some of the smaller stock sizes.

Size	Cu. Ft. Air per Min.	Horsepower	Speed R. P. M.	Height, Inches
No. 1	90	1/30	1800	8¼
No. 2	250	⅛	1800	10½
No. 3	500	¼	1800	15

Planoidal Type "L" Fan Wheel

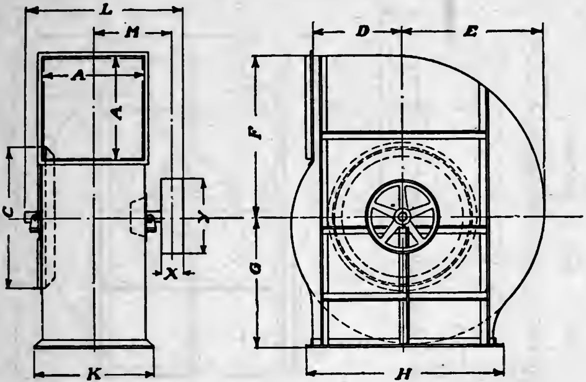
Cowl Ventilator

SECTION IV

FAN DIMENSIONS

Included in this section will be found dimensions of various fans and blowers. Dimensions of Planoidal, Niagara Conoidal and Turbo-Conoidal fans are given for both full and three-quarter housing, for top horizontal, bottom horizontal, up and down discharge. Dimensions are given on pages 382 to 385 for double width Niagara Conoidal and Turbo-Conoidal fans. Dimensions of slow speed and standard planing-mill exhausters, single and double width, will be found on pages 394 to 397, and on page 398 are given dimensions of steel pressure blowers.

PLANOIDAL (TYPE L) FANS



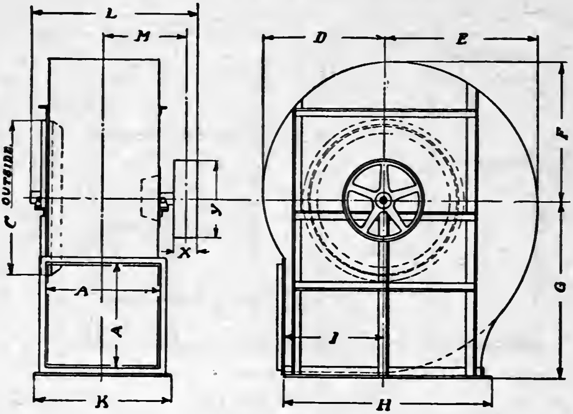
OVERHUNG PULLEY
FULL HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	C		D	E	F	G	H	K	L	M	X	Y
		Exh.	Blow.										
30	10 3/4	13 1/4	11 5/8	10 1/2	14 7/8	16 5/8	14 1/8	25	15	25 1/4	13 1/4	3	8
35	12 1/2	15 3/8	13 1/2	12	17 1/4	19 1/4	16 1/4	28	16 3/4	27 1/8	14 1/4	3	9
40	14 1/4	17 1/2	15 1/2	13 1/2	19 5/8	21 7/8	18 3/8	31	18 1/2	28 3/4	15	3	10
45	16 1/8	19 5/8	17 3/8	15	22 3/8	25	20 3/4	34	20 3/8	30 11/16	16	3	11
50	17 7/8	23	19 1/4	16 1/2	24 3/4	27 5/8	22 7/8	37	22 1/8	33 5/16	17 1/4	4	12
55	19 5/8	25 1/2	21 1/4	18	27	30 1/8	24 7/8	40	23 7/8	35 7/16	18 1/4	4	14
60	21 1/2	28 1/2	23 1/8	19 1/2	29 3/8	32 3/4	27	43	25 3/4	39 1/8	20	5	16
70	25	35	27	23	34 1/2	38 1/2	31 1/2	50	29 1/4	45 3/8	21 3/4	5	18
80	28 1/2	40	30 7/8	26	39 5/8	44 1/4	36	56	32 3/4	49 3/8	25	6	20
90	32 1/4	45	34 3/4	29	44 3/8	49 1/2	40 1/4	62	36 1/2	53 1/4	27	6	24
100	35 3/4	50	38 5/8	32	49 3/8	55 1/8	44 5/8	68	40	58 1/2	29 1/2	7	26
110	39 1/4	55	42 1/2	35	54 1/8	60 3/8	48 7/8	75	44 1/2	63	31 3/4	8	28
120	43	60	46 1/4	38	59 1/4	66 1/8	53 3/8	81	48 1/4	66 5/8	33 1/2	8	30
130	46 1/2	65	50 1/8	41	63 7/8	71 1/4	57 1/2	88	52 3/4	73 5/8	37	9	34
140	50	70	54	44	69	77	62	94	56 1/4	77 7/8	39	10	36
150	53 1/2	75	57 7/8	47	73 3/4	82 1/4	66 1/4	100	59 3/4	85 7/8	43	11	38
160	57	80	61 3/4	50	78 7/8	88	70 3/4	107	64 1/4	90 1/8	45	12	40
170	60 3/4	85	65 5/8	54	83 7/8	93 5/8	75 1/8	116	69	95	47 1/2	13	44
180	64 1/4	90	69 1/2	57	88 5/8	98 7/8	79 3/8	122	72 1/2	103	51 1/2	14	46
190	67 3/4	95	73 1/4	60	93 3/4	104 5/8	83 7/8	128	76	107 1/2	53 3/4	15	48
200	71 1/2	100	77 1/4	63	98 3/4	110 1/4	88 1/4	134	79 3/4	115 7/8	58	16	50

Note—Blowers have two Inlets but no Inlet Cone.

PLANOIDAL (TYPE L) FANS



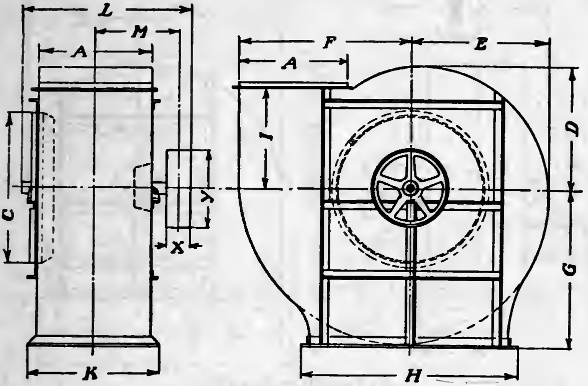
OVERHUNG PULLEY
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	C		D	E	F	G	H	I	K	L	M	X	Y
		Exh.	Blow.											
30	10¾	13¼	11⅝	11⅜	14⅞	13⅛	17⅝	23	10½	15	25¼	13¼	3	8
35	12½	15⅜	13½	13¼	17¼	15¼	20¼	26	12	16¾	27⅛	14¼	3	9
40	14¼	17½	15½	15⅛	19⅝	17⅜	22⅞	29	13½	18½	28¾	15	3	10
45	16⅛	19⅝	17⅜	17⅛	22⅜	19¾	26	32	15	20⅜	30 11/16	16	3	11
50	17⅞	23	19¼	19	24¾	21⅞	28⅝	35	16½	22⅛	33 5/16	17¼	4	12
55	19⅝	25½	21¼	20¾	27	23⅞	31⅛	38	18	23⅞	35 7/16	18¼	4	14
60	21½	28½	23⅛	22⅝	29⅜	26	33¾	41	19½	25¾	39⅛	20	5	16
70	25	35	27	26½	34½	30½	40	48	23	29¼	45⅜	21¾	5	18
80	28½	40	30⅞	30⅜	39⅝	35	45¾	54	26	32¾	49⅜	25	6	20
90	32¼	45	34¾	34⅛	44⅜	39¼	51	60	29	36½	53¼	27	6	24
100	35¾	50	38⅝	37⅞	49⅜	43⅝	56⅝	66	32	40	58½	29½	7	26
110	39¼	55	42½	41⅝	54⅛	47⅞	61⅞	72½	35	44½	63	31¾	8	28
120	43	60	46¼	45½	59¼	52⅜	67⅝	78½	38	48¼	66⅝	33½	8	30
130	46½	65	50⅛	49⅛	63⅞	56½	72¾	85	41	52¾	73⅝	37	9	34
140	50	70	54	53	69	61	78½	91	44	56¼	77⅞	39	10	36
150	53½	75	57⅞	56¾	73¾	65¼	83¾	97	47	59¾	85⅞	43	11	38
160	57	80	61¾	60⅝	78⅞	69¾	89½	103½	50	64¼	90⅛	45	12	40
170	60¾	85	65⅝	64⅜	83⅞	74⅛	95⅛	112	54	69	95	47½	13	44
180	64¼	90	69½	68⅛	88⅝	78⅜	100⅜	118	57	72½	103	51½	14	46
190	67¾	95	73¼	72	93¾	82⅞	106⅛	124	60	76	107½	53¾	15	48
200	71½	100	77¼	75¾	98¾	87¼	111¾	130	63	79¾	115⅞	58	16	50

Note—Blowers have two Inlets but no Inlet Cone.

PLANOIDAL (TYPE L) FANS



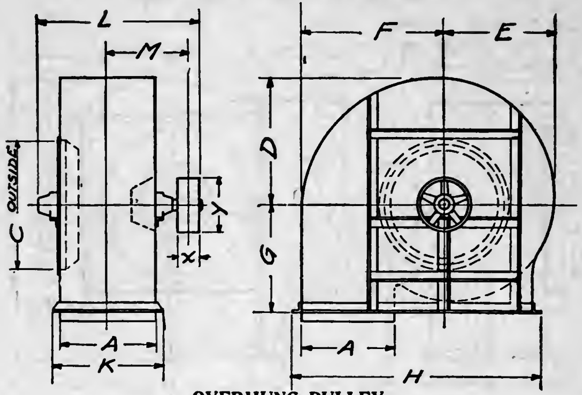
OVERHUNG PULLEY
FULL HOUSING—UP DISCHARGE

Dimensions in Inches

Size	A	C		D	E	F	G	H	I	K	L	M	X	Y
		Exh.	Blow.											
30	10¾	13¼	11⅝	11⅜	13⅛	16⅝	15⅞	25	10½	15	25¼	13¼	3	8
35	12½	15⅜	13½	13¼	15¼	19¼	18¼	28	12	16¾	27⅛	14¼	3	9
40	14¼	17½	15½	15⅛	17⅜	21⅞	20⅝	31	13½	18½	28¾	15	3	10
45	16⅛	19⅝	17⅜	17⅛	19¾	25	23⅜	34	15	20⅜	30 11/16	16	3	11
50	17⅞	23	19¼	19	21⅞	27⅝	25¾	37	16½	22⅛	33 5/16	17¼	4	12
55	19⅝	25½	21¼	20¾	23⅞	30⅛	28	40	18	23⅞	35 7/16	18¼	4	14
60	21½	28½	23⅛	22⅝	26	32¾	30⅜	43	19½	25¾	39⅛	20	5	16
70	25	35	27	26½	30½	38½	35½	50	23	29¼	45⅜	21¾	5	18
80	28½	40	30⅞	30⅜	35	44¼	40⅝	56	26	32¾	49⅜	25	6	20
90	32¼	45	34¾	34⅛	39¼	49½	45⅜	62	29	36½	53¼	27	6	24
100	35¾	50	38⅝	37⅞	43⅝	55⅛	50⅜	68	32	40	58½	29½	7	26
110	39¼	55	42½	41⅝	47⅞	60⅜	55⅛	75	35	44½	63	31¾	8	28
120	43	60	46¼	45½	52⅜	66⅛	60¼	81	38	48¼	66⅝	33½	8	30
130	46½	65	50⅛	49⅛	56½	71¼	64⅞	88	41	52¾	73⅝	37	9	34
140	50	70	54	53	61	77	70	94	44	56¼	77⅞	39	10	36
150	53½	75	57⅞	56¾	65¼	82¼	74¾	100	47	59¾	85⅞	43	11	38
160	57	80	61¾	60⅝	69¾	88	79⅞	107	50	64¼	90⅛	45	12	40
170	60¾	85	65⅝	64⅜	74⅛	93⅝	84⅞	116	54	69	95	47½	13	44
180	64¼	90	69½	68⅛	78⅜	98⅞	89⅝	122	57	72½	103	51½	14	46
190	67¾	95	73¼	72	82⅞	104⅝	94¾	128	60	76	107½	53¾	15	48
200	71½	100	77¼	75¾	87¼	110¼	99¾	134	63	79¾	115⅞	58	16	50

Note—Blowers have two Inlets but no Inlet Cone.

PLANOIDAL (TYPE L) FANS



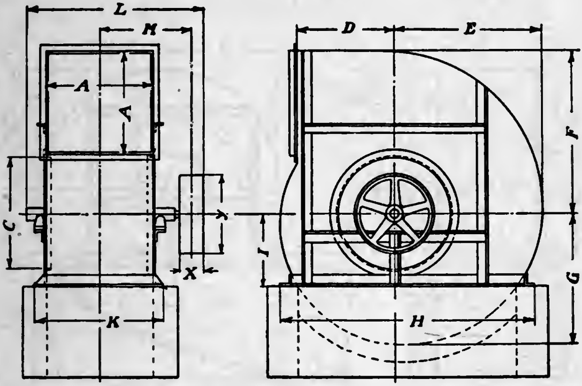
OVERHUNG PULLEY
FULL HOUSING—DOWN DISCHARGE

Dimensions in Inches

Size	A	C		D	E	F	G	H	K	L	M	X	Y
		Exh.	Blow.										
30	10¾	13¼	11⅝	14⅞	13⅛	16⅝	12⅜	31⅛	15	25¼	13¼	3	8
35	12½	15⅜	13½	17¼	15¼	19¼	14¼	35¼	16¾	27⅛	14¼	3	9
40	14¼	17½	15½	19⅝	17⅜	21⅞	16⅛	39⅜	18½	28¾	15	3	10
45	16⅛	19⅝	17⅜	22⅜	19¾	25	18⅛	44	20⅜	30 11/16	16	3	11
50	17⅞	23	19¼	24¾	21⅞	27⅝	20	48⅛	22⅛	33 5/16	17¼	4	12
55	19⅝	25½	21¼	27	23⅞	30⅛	21¾	52⅛	23⅞	35 7/16	18¼	4	14
60	21½	28½	23⅛	29⅜	26	32¾	23⅝	56¼	25¾	39⅛	20	5	16
70	25	35	27	34½	30½	38½	27½	65½	29¼	45⅜	21¾	5	18
80	28½	40	30⅞	39⅝	35	44¼	31⅜	74¼	32¾	49⅜	25	6	20
90	32¼	45	34¾	44⅜	39¼	49½	35⅛	82½	36½	53¼	27	6	24
100	35¾	50	38⅝	49⅜	43⅝	55⅛	38⅞	91⅛	40	58½	29½	7	26
110	39¼	55	42½	54⅛	47⅞	60⅜	42⅝	100⅜	44½	63	31¾	8	28
120	43	60	46¼	59¼	52⅜	66⅛	46½	109⅛	48¼	66⅝	33½	8	30
130	46½	65	50⅛	63⅞	56½	71¼	50⅛	118¼	52¾	73⅝	37	9	34
140	50	70	54	69	61	77	54	127	56¼	77⅞	39	10	36
150	53½	75	57⅞	73¾	65¼	82¼	57¾	135¼	59¾	85⅞	43	11	38
160	57	80	61¾	78⅞	69¾	88	61⅝	145	64¼	90⅛	45	12	40
170	60¾	85	65⅝	83⅞	74⅛	93⅝	65⅜	155⅝	69	95	47½	13	44
180	64¼	90	69½	88⅝	78⅜	98⅞	69⅛	163⅞	72½	103	51½	14	46
190	67¾	95	73¼	93¾	82⅞	104⅝	73	172⅝	76	107½	53¾	15	48
200	71½	100	77¼	98¾	87¼	110¼	76¾	181¼	79¾	115⅞	58	16	50

Note—Blowers have two Inlets but no Inlet Cone.

PLANOIDAL (TYPE L) EXHAUSTERS

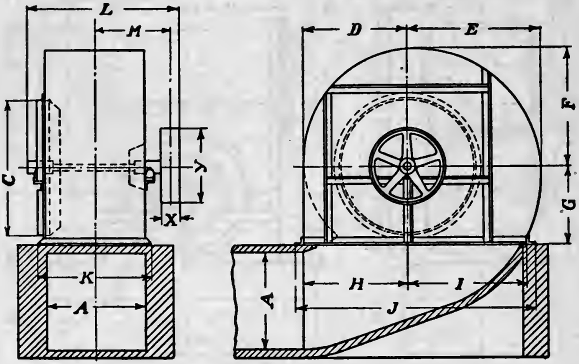


OVERHUNG PULLEY
THREE-QUARTER HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	C	D	E	F	G	H	I	K	L	M	X	Y
60	21½	28½	19½	29⅜	32¾	26	45⅞	18	25¾	39⅛	20	5	16
70	25	35	23	34½	38½	30½	53¼	20½	29¼	45⅜	21¾	5	18
80	28½	40	26	39⅝	44¼	35	60⅝	23½	32¾	49⅜	25	6	20
90	32¼	45	29	44⅜	49½	39¼	67⅝	26	36½	53¼	27	6	24
100	35¾	50	32	49⅜	55⅛	43⅝	74½	28½	40	58½	29½	7	26
110	39¼	55	35	54⅛	60⅜	47⅞	82¼	31½	44½	63	31¾	8	28
120	43	60	38	59¼	66⅛	52⅜	89¾	34	48¼	66⅝	33½	8	30
130	46½	65	41	63⅞	71¼	56½	97¾	37	52¾	73⅝	37	9	34
140	50	70	44	69	77	61	105¼	39½	56¼	77⅞	39	10	36
150	53½	75	47	73¾	82¼	65¼	111⅜	42½	59¾	85⅞	43	11	38
160	57	80	50	78⅞	88	69¾	120	46	64¼	90⅛	45	12	40
170	60¾	85	54	83⅞	93⅝	74⅛	127⅞	48½	69	95	47½	13	44
180	64¼	90	57	88⅝	98⅞	78⅜	134⅞	51	72½	103	51½	14	46
190	67¾	95	60	93¾	104⅝	82⅞	141⅝	54	76	107½	53¾	15	48
200	71½	100	63	98¾	110¼	87¼	148¾	56½	79¾	115⅞	58	16	50

PLANOIDAL (TYPE L) EXHAUSTERS

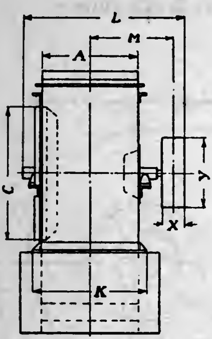


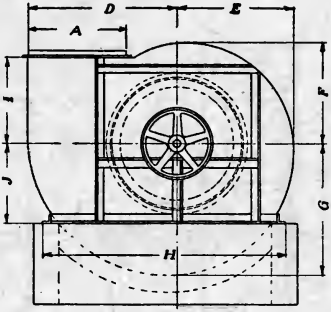
OVERHUNG PULLEY
THREE-QUARTER HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	C	D	E	F	G	H	I	J	K	L	M	X	Y
60	21 ½	28 ½	22 ⅝	29 ⅜	26	18	22 ⅝	26 ⅛	52 ¾	25 ¾	39 ⅛	20	5	16
70	25	35	26 ½	34 ½	30 ½	20 ½	26 ½	30 ¾	61 ¼	29	45 ⅜	21 ¾	5	18
80	28 ½	40	30 ⅜	39 ⅝	35	23 ½	30 ⅜	35 ½	69 ⅞	32 ¾	49 ⅜	25	6	20
90	32 ¼	45	34 ⅛	44 ⅜	39 ¼	26	34 ⅛	40	78 ⅛	36 ½	53 ¼	27	6	24
100	35 ¾	50	37 ⅞	49 ⅜	43 ⅝	28 ½	37 ⅞	44 ¼	86 ⅛	40	58 ½	29 ½	7	26
110	39 ¼	55	41 ⅝	54 ⅛	47 ⅞	31 ½	41 ⅝	48 ⅝	95 ¼	44 ½	63	31 ¾	8	28
120	43	60	45 ½	59 ¼	52 ⅜	34	45 ½	53	103 ½	48 ¼	66 ⅝	33 ½	8	30
130	46 ½	65	49 ⅛	63 ⅞	56 ½	37	49 ⅛	57 ⅛	112 ¼	52 ¾	73 ⅝	37	9	34
140	50	70	53	69	61	39 ½	53	61 ¾	120 ¾	56 ¼	77 ⅞	39	10	36
150	53 ½	75	56 ¾	73 ¾	65 ¼	42 ½	56 ¾	65 ⅞	128 ⅝	59 ¾	85 ⅞	43	11	38
160	57	80	60 ⅝	78 ⅞	69 ¾	46	60 ⅝	70 ½	138 ⅛	64 ¼	90 ⅛	45	12	40
170	60 ¾	85	64 ⅜	83 ⅞	74 ⅛	48 ½	64 ⅜	75 ⅛	147 ½	69	95	47 ½	13	44
180	64 ¼	90	68 ⅛	88 ⅝	78 ⅜	51	68 ⅛	79 ⅜	155 ½	72 ½	103	51 ½	14	46
190	67 ¾	95	72	93 ¾	82 ⅞	54	72	83 ⅝	163 ⅝	76	107 ½	53 ¾	15	48
200	71 ½	100	75 ¾	98 ¾	87 ¼	56 ½	75 ¾	88 ¼	172	79 ¾	115 ⅞	58	16	50

PLANOIDAL (TYPE L) EXHAUSTERS





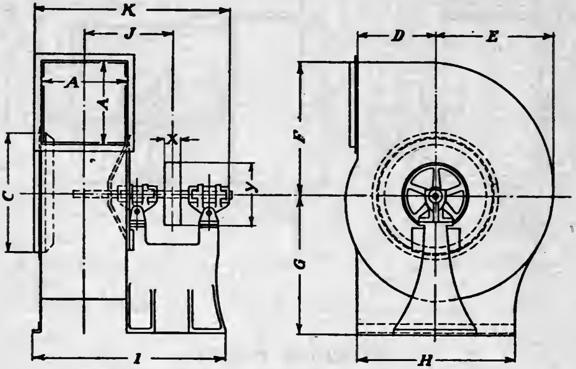
OVERHUNG PULLEY
THREE-QUARTER HOUSING—UP DISCHARGE

Dimensions in Inches

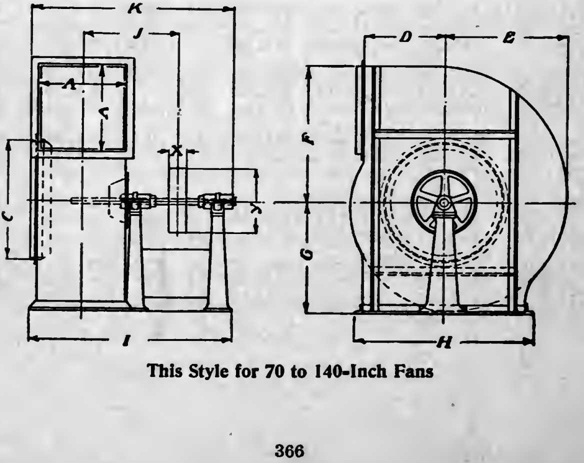
Size	A	C	D	E	F	G	H	I	J	K	L	M	X	Y
60	21 ½	28 ½	32 ¾	26	22 ⅝	29 ⅜	53 ⅞	19 ½	18	25 ¾	39 ⅛	20	5	16
70	25	35	38 ½	30 ½	26 ½	34 ½	62 ¾	23	20 ½	29 ¼	45 ⅜	21 ¾	5	18
80	28 ½	40	44 ¼	35	30 ⅜	39 ⅝	71 ¾	26	23 ½	32 ¾	49 ⅜	25	6	20
90	32 ¼	45	49 ½	39 ¼	34 ⅛	44 ⅜	79 ⅞	29	26	36 ½	53 ¼	27	6	24
100	35 ¾	50	55 ⅛	43 ⅝	37 ⅞	49 ⅜	88 ¼	32	28 ½	40	58 ½	29 ½	7	26
110	39 ¼	55	60 ⅜	47 ⅞	41 ⅝	54 ⅛	97 ¼	35	31 ½	44 ½	63	31 ¾	8	28
120	43	60	66 ⅛	52 ⅜	45 ½	59 ¼	106 ⅝	38	34	48 ¼	66 ⅝	33 ½	8	30
130	46 ½	65	71 ¼	56 ½	49 ⅛	63 ⅞	115 ⅜	41	37	52 ¾	73 ⅝	37	9	34
140	50	70	77	61	53	69	124 ⅜	44	39 ½	56 ¼	77 ⅞	39	10	36
150	53 ½	75	82 ¼	65 ¼	56 ¾	73 ¾	132	47	42 ½	59 ¾	85 ⅞	43	11	38
160	57	80	88	69 ¾	60 ⅝	78 ⅞	141 ¾	50	46	64 ¼	90 ⅛	45	12	40
170	60 ¾	85	93 ⅝	74 ⅛	64 ⅜	83 ⅞	151 ½	54	48 ½	69	95	47 ½	13	44
180	64 ¼	90	98 ⅞	78 ⅜	68 ⅛	88 ⅝	159 ½	57	51	72 ½	103	51 ½	14	46
190	67 ¾	95	104 ⅝	82 ⅞	72	93 ¾	167 ⅞	60	54	76	107 ½	53 ¾	15	48
200	71 ½	100	110 ¼	87 ¼	75 ¾	98 ¾	176 ½	63	56 ½	79 ¾	115 ⅞	58	16	50

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL
FULL HOUSING—TOP HORIZONTAL DISCHARGE



This Style for 30 to 60-Inch Fans



This Style for 70 to 140-Inch Fans

PLANOIDAL (TYPE L) EXHAUSTERS

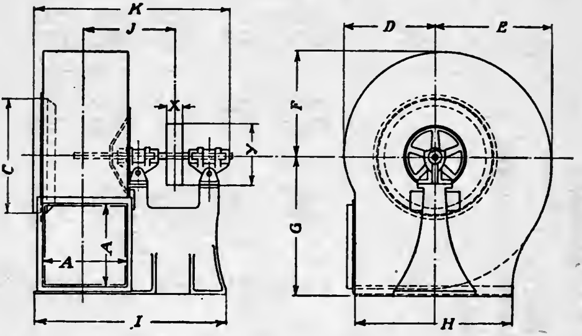
OVERHUNG WHEEL
FULL HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

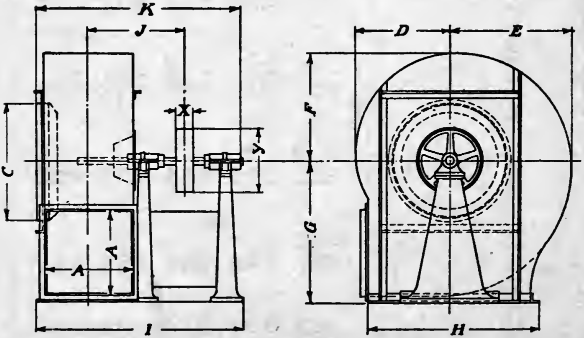
Size	A	C	D	E	F	G	H	I	J	K	X	Y
30	10¾	13¼	10½	14⅞	16⅝	18	21	31	14¼	31¼	3	8
35	12½	15⅜	12	17¼	19¼	20¾	24	35 1/16	15⅝	34⅛	3	9
40	14¼	17½	13½	19⅝	21⅞	24	27	38¼	17½	37½	3	10
45	16⅛	19⅝	15	22⅜	25	26⅝	30	41⅞	19 9/16	42	3	11
50	17⅞	23	16½	24¾	27⅝	29¼	33	45 3/16	20 15/16	44¾	4	12
55	19⅝	25½	18	27	30⅛	32	36	48⅞	22 5/16	49	4	14
60	21½	28½	19½	29⅜	32¾	35	39	51¾	24⅜	51⅞	5	16
70	25	35	23	34½	38½	31½	50	57¼	27⅛	56⅝	5	18
80	28½	40	26	39⅝	44¼	36	56	60¾	28⅞	61⅜	6	20
90	32¼	45	29	44⅜	49½	40¼	62	64½	30¾	65⅛	6	24
100	35¾	50	32	49⅜	55⅛	44⅝	68	81½	38½	78⅛	7	26
110	39¼	55	35	54⅛	60⅜	48⅞	75	85½	40¼	81⅛	8	28
120	43	60	38	59¼	66⅛	53⅜	81	89¼	42⅛	84⅞	8	30
130	46½	65	41	63⅞	71¼	57½	88	93¼	43⅞	89⅜	9	34
140	50	70	44	69	77	62	94	96¼	45⅝	92⅞	10	36

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE



This Style for 30 to 60-Inch Fans



This Style for 70 to 140-Inch Fans

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL

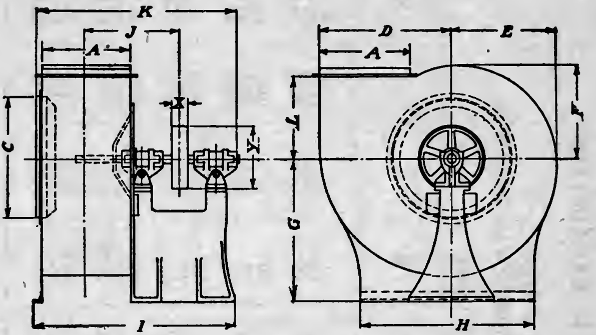
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

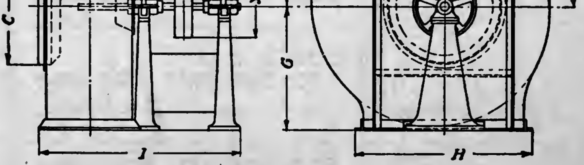
Size	A	C	D	E	F	G	H	I	J	K	X	Y
30	10¾	13¼	11⅜	14¾	13⅛	18	21	31	14¼	31¼	3	8
35	12½	15⅜	13¼	17 3/16	15¼	20¾	24	35 1/16	15⅝	34⅛	3	9
40	14¼	17½	15⅛	19⅝	17⅜	24	27	38¼	17½	37½	3	10
45	16⅛	19⅝	17⅛	22⅜	19¾	26⅝	30	41⅞	19⅝	42	3	11
50	17⅞	23	19	24¾	21⅞	29¼	33	45 3/16	20 15/16	44¾	4	12
55	19⅝	25½	20¾	27	23⅞	32	36	48⅞	22 15/16	49	4	14
60	21½	28½	22⅝	29⅜	26	35	39	51¾	24⅜	51⅞	5	16
70	25	35	26½	34½	30½	40	48	57¼	27⅛	56⅝	5	18
80	28½	40	30⅜	39⅝	35	45¾	54	60¾	28⅞	61⅜	6	20
90	32¼	45	34⅛	44⅜	39¼	51	60	64½	30¾	65⅛	6	24
100	35¾	50	37⅞	49⅜	43⅝	56⅝	66	81½	38½	78⅛	7	26
110	39¼	55	41⅝	54⅛	47⅞	61⅞	72½	85½	40¼	81⅛	8	28
120	43	60	45½	59¼	52⅜	67⅝	78½	89¼	42⅛	84⅞	8	30
130	46½	65	49⅛	63⅞	56½	72¾	85	93¼	43⅞	89⅜	9	34
140	50	70	53	69	61	78½	91	96¾	45⅝	92⅞	10	36

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL
FULL HOUSING—UP DISCHARGE



This Style for 30 to 60-Inch Fans



This Style for 70 to 140-Inch Fans

PLANOIDAL (TYPE L) EXHAUSTERS

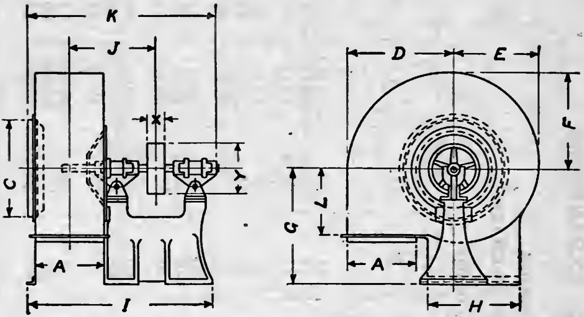
OVERHUNG WHEEL
FULL HOUSING—UP DISCHARGE

Dimensions in Inches

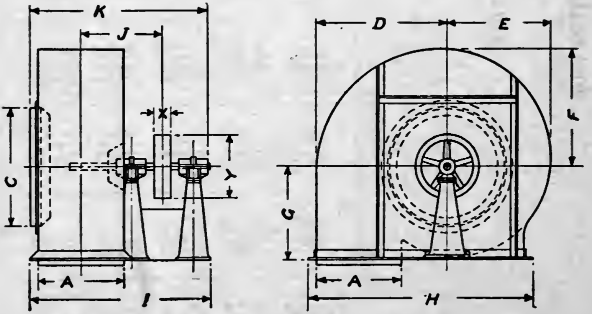
Size	A	C	D	E	F	G	H	I	J	K	X	Y
30	10¾	13¼	16⅝	13⅛	11⅜	18	21	31	14¼	31¼	3	8
35	12½	15⅜	18¼	15¼	13¼	20¾	24	35 1/16	15⅝	34⅛	3	9
40	14¼	17½	21⅞	17⅜	15⅞	24	27	38¼	17½	37½	3	10
45	16⅛	19⅝	25	19¾	17⅛	26⅝	30	41⅞	19⅝	42	3	11
50	17⅞	23	27⅝	21⅞	19	29¼	33	45 3/16	20 15/16	44¾	4	12
55	19⅝	25½	30⅛	23⅞	20¾	32	36	48⅞	22 15/16	49	4	14
60	21½	28½	32¾	26	22⅝	35	39	51¾	24⅜	51⅞	5	16
70	25	35	38½	30½	26½	35½	48	57¼	27⅛	56⅝	5	18
80	28½	40	44¼	35	30⅜	40⅝	54	60¾	28⅞	61⅜	6	20
90	32¼	45	49½	39¼	34⅛	45⅜	60	64½	30¾	65⅛	6	24
100	35¾	50	55⅛	43⅝	37⅛	50⅜	66	81½	38½	78⅛	7	26
110	39¼	55	60⅜	47⅞	41⅝	55⅛	72½	85½	40¼	81⅛	8	28
120	43	60	66⅛	52⅜	45½	60¼	78½	89¼	42⅛	84⅞	8	30
130	46½	65	71¼	56½	49⅛	64⅞	85	93¼	43⅞	89⅜	9	34
140	50	70	77	61	53	70	91	96¾	45⅝	92⅞	10	36

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL
FULL HOUSING—DOWN DISCHARGE



This Style for 30 to 60-Inch Fans



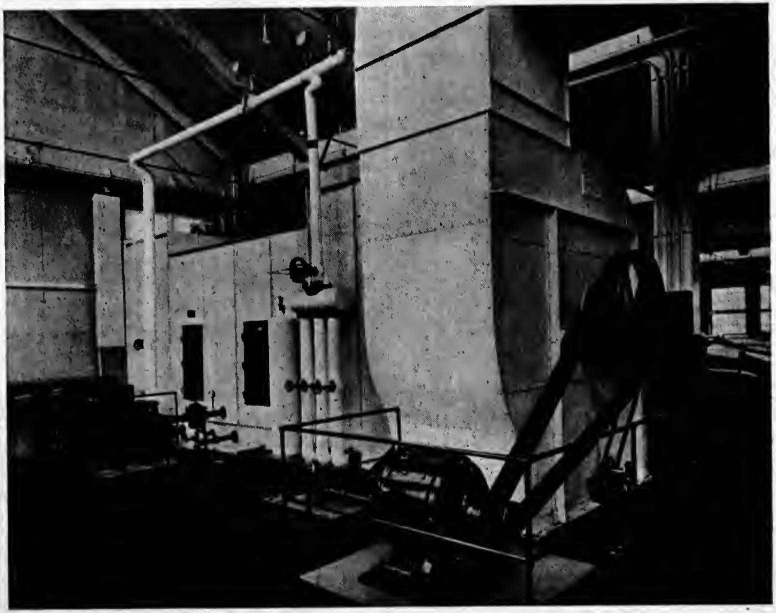
This Style for 70 to 140-Inch Fans

PLANOIDAL (TYPE L) EXHAUSTERS

OVERHUNG WHEEL
FULL HOUSING—DOWN DISCHARGE

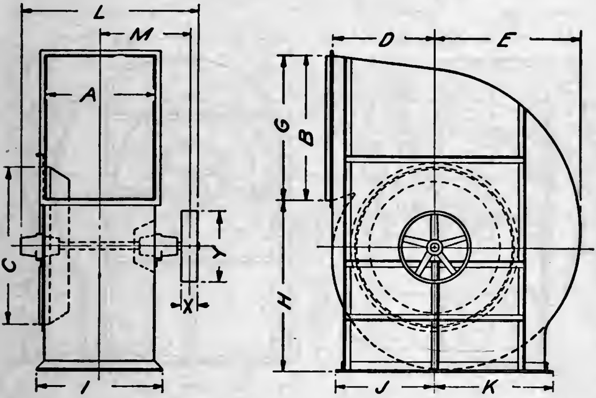
Dimensions in Inches

Size	A	C	D	E	F	G	H	I	J	K	L	X	Y
30	10¾	13¼	16⅝	13⅛	14⅞	18	14½	31	14¼	31¼	10½	3	8
35	12½	15⅜	19¼	15¼	17¼	20¾	16¾	35 1/16	15⅝	34⅛	12	3	9
40	14¼	17½	21⅞	17⅜	19⅝	24	19¼	38¼	17½	37½	13½	3	10
45	16⅛	19⅝	25	19¾	22⅜	26⅝	22	41⅞	19 9/16	42	15	3	11
50	17⅞	23	27⅝	21⅞	24¾	29¼	24¼	45 3/16	20 15/16	44¾	16½	4	12
55	19⅝	25½	30⅛	23⅞	27	32	26½	48⅞	22 13/16	49	18	4	14
60	21½	28½	32¾	26	29⅜	35	28¾	51¾	24⅜	51⅞	19½	5	16
70	25	35	38½	30½	34½	27½	65½	57¼	27⅛	56⅝		5	18
80	28½	40	44¼	35	39⅝	31⅜	74¼	60¾	28⅞	61⅜		6	20
90	32¼	45	49½	39¼	44⅜	35⅛	82½	64½	30¾	65⅛		6	24
100	35¾	50	55⅛	43⅝	49⅜	38⅞	91⅛	81½	38½	78⅛		7	26
110	39¼	55	60⅜	47⅞	54⅛	42⅝	100⅜	85½	40¼	81⅛		8	28
120	43	60	66⅛	52⅜	59¼	46½	109⅛	89¼	42⅛	84⅞		8	30
130	46½	65	71¼	56½	63⅞	50⅛	118¼	93¼	43⅞	89⅜		9	34
140	50	70	77	61	69	54	127	96¾	45⅝	92⅞		10	36



Planoidal Type "L" Fan and Heater Installed with Humidifier

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

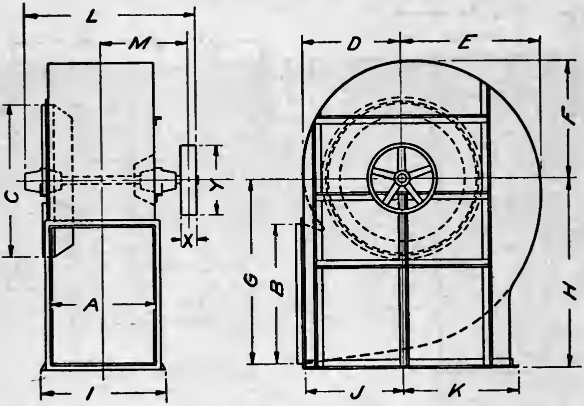


OVERHUNG PULLEY
FULL HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	20 13/16	14	16 1/4	13 1/4	14	27	14 1/2	3	8
3 1/2	14	18 3/8	20	13	18 9/16	24 1/4	16 1/2	18 1/4	15	16	29	15 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	27 3/4	18 1/2	20 1/4	16 7/8	18	31	16 1/2	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	31 1/4	21	22 1/4	18 3/4	20	33	17 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	34 11/16	23	24 1/4	19 1/2	22	35	18 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	38 3/16	25	26 1/4	21 1/4	24	36 1/2	18 1/2	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	41 5/8	27 1/2	28 1/4	23	26	40	20 1/2	3	16
7	28	36 3/4	39 3/4	26	37 1/8	48 9/16	32	32 1/4	26 1/2	30	47	24	4	18
8	32	42	45 1/2	29 3/4	42 3/8	55 1/2	36 1/2	36 1/4	28 3/4	34	53	27	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	62 7/16	41	40 1/4	31 3/4	38	61	31	6	24
10	40	52 1/2	56 3/4	37 3/16	53	69 3/8	45	44 1/4	34 3/4	42	65	33	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16	76 5/16	49 1/2	49 1/4	38 3/8	46 1/2	73 1/2	37	8	28
12	48	63	68	44 5/8	63 5/8	83 1/4	54	53 1/4	41 7/8	50 1/2	79 1/2	39 1/2	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8	90 3/16	58 1/2	58 1/4	45 3/8	55	83	41 1/2	10	34
14	56	73 1/2	79	52 1/16	74 3/16	97 1/8	63	62 1/4	47 3/8	59	92	46	11	36
15	60	78 3/4	84 3/4	55 3/4	79 1/2	104 1/16	67 1/2	66 1/4	51 3/8	63	99	49 1/2	14	38
16	64	84	90 1/4	59 1/2	84 3/4	111	72	71 1/4	54 7/8	67 1/2	107	53 1/2		40
17	68	89 1/4	96	63 1/4	90 1/16	117 15/16	76	76 1/4	58 3/8	72	112	56		44
18	72	94 1/2	101 1/2	66 15/16	95 3/8	124 7/8	80 1/2	80 1/4	61 3/8	76	120	60		46
19	76	99 3/4	107	70 11/16	100 11/16	131 13/16	85	84 1/4	64 3/8	80	125	62 1/2		48
20	80	105	112 3/4	74 5/8	106	138 3/4	89 1/2	88 1/4	67 3/8	84	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

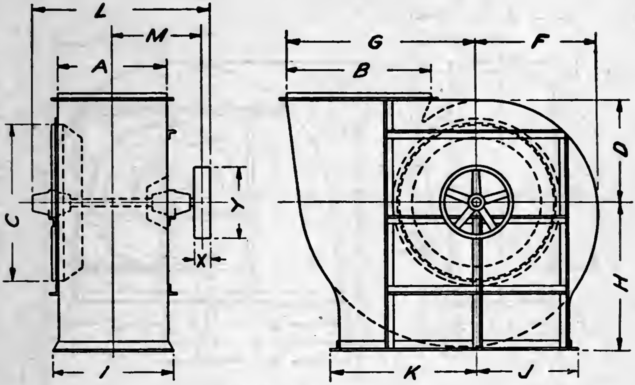


OVERHUNG PULLEY
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	13 1/4	20 13/16	22	16 1/4	11 3/16	14	27	14 1/2	3	8
3 1/2	14	18 3/8	20	13	18 9/16	15 7/16	24 1/4	25 1/2	18 1/4	13	16	29	15 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	17 5/8	27 3/4	29	20 1/4	14 7/8	18	31	16 1/2	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	19 7/8	31 1/4	32 1/2	22 1/4	16 3/4	20	33	17 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	22 1/16	34 11/16	36	24 1/4	18 5/8	22	35	18 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	24 1/4	38 3/16	39 1/2	26 1/4	20 7/16	24	36 1/2	18 1/2	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	26 1/2	41 5/8	43	28 1/4	22 5/16	26	40	20 1/2	3	16
7	28	36 3/4	39 3/4	26	37 1/8	30 7/8	48 9/16	50	32 1/4	26	30	47	24	4	18
8	32	42	45 1/2	29 3/4	42 3/8	35 5/16	55 1/2	57	36 1/4	29 3/4	34	53	27	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	39 3/4	62 7/16	64	40 1/4	33 1/2	38	61	31	6	24
10	40	52 1/2	56 3/4	37 3/16	53	44 1/8	69 3/8	71	44 1/4	37 3/16	42	65	33	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16	48 1/2	76 5/16	78	49 1/4	40 15/16	46 1/2	73 1/2	37	8	28
12	48	63	68	44 5/8	63 5/8	52 15/16	83 1/4	85	53 1/4	44 5/8	50 1/2	79 1/2	39 1/2	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8	57 3/8	90 3/16	92	58 1/4	48 3/8	55	83	41 1/2	10	34
14	56	73 1/2	79	52 1/16	74 3/16	61 3/4	97 1/8	99	62 1/4	52 1/16	59	92	46	11	36
15	60	78 3/4	84 3/4	55 3/4	79 1/2	66 3/16	104 1/16	106	66 1/4	55 3/4	63	99	49 1/2	14	38
16	64	84	90 1/4	59 1/2	84 3/4	70 5/8	111	112 1/2	71 1/4	59 1/2	67 1/2	107	53 1/2		40
17	68	89 1/4	96	63 1/4	90 1/16	75	117 15/16	119 1/2	76 1/4	63 1/4	72	112	56		44
18	72	94 1/2	101 1/2	66 15/16	95 3/8	79 7/16	124 7/8	126 1/2	80 1/4	66 15/16	76	120	60		46
19	76	99 3/4	107	70 11/16	100 11/16	83 13/16	131 13/16	133 1/2	84 1/4	70 11/16	80	125	62 1/2		48
20	80	105	112 3/4	74 3/8	106	88 1/4	138 3/4	140 1/2	88 1/4	74 3/8	84	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

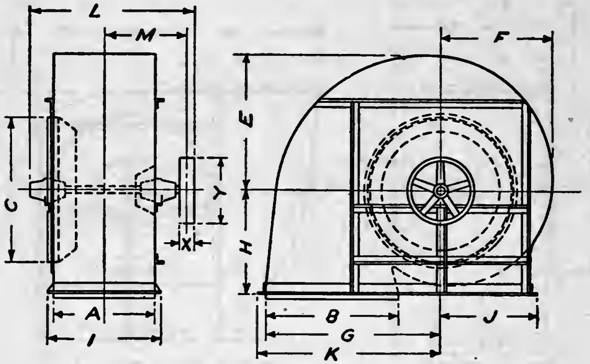


OVERHUNG PULLEY
FULL HOUSING—UP DISCHARGE

Dimensions in Inches

Size	A	B	C	D	F	G	H	I	J	K	L	M	X	Y
3	12	15¾	17¼	11 3/16	13¼	20 13/16	17	16¼	13¼	17	27	14½	3	8
3½	14	18⅜	20	13	15 7/16	24¼	19½	18¼	15	19½	29	15½	3	9
4	16	21	22¾	14⅞	17⅝	27¾	22½	20¼	17	22	31	16½	3	10
4½	18	23⅝	25¾	16¾	19⅞	31¼	25	22¼	18¾	24½	33	17½	3	11
5	20	26¼	28½	18⅝	22 1/16	34 11/16	27½	24¼	19½	27	35	18½	3	12
5½	22	28⅞	31½	20 7/16	24¼	38 3/16	30	26¼	21¼	29½	36½	18½	3	14
6	24	31½	34¼	22 5/16	26½	41⅝	33	28¼	23	32	40	20½	3	16
7	28	36¾	39¾	23	30⅞	48 9/16	38	32¼	26½	37	47	24	4	18
8	32	42	45½	29¾	35 5/16	55½	43½	36¼	28¾	42	53	27	5	20
9	36	47¼	51¼	33½	39¾	62 7/16	49	40¼	31¾	47	61	31	6	24
10	40	52½	56¾	37 3/16	44⅛	69⅜	54	44¼	34⅞	52	65	33	6	26
11	44	57¾	62½	40 15/16	48½	76 5/16	59½	49¼	38⅜	57½	73½	37	8	28
12	48	63	68	44⅝	52 15/16	83¼	65	53¼	41⅞	62½	79½	39½	9	30
13	52	68¼	73½	48⅜	57⅜	90 3/16	70	58¼	45⅜	68	83	41½	10	34
14	56	73½	79	52 1/16	61¾	97⅛	75½	62¼	47⅜	73	92	46	11	36
15	60	78¾	84¾	55¾	66 3/16	104 1/16	80½	66¼	51⅜	78	99	49½	14	38
16	64	84	90¼	59½	70⅝	111	86	71¼	54⅞	83½	107	53½		40
17	68	89¼	96	63¼	75	117 15/16	91	76¼	58⅜	89	112	56		44
18	72	94½	101½	66 15/16	79 7/16	124⅞	96½	80¼	61⅜	94	120	60		46
19	76	99¾	107	70 11/16	83 13/16	131 13/16	102	84¼	64⅜	99	125	62½		48
20	80	105	112¾	74⅜	88¼	138¾	107	88¼	67⅜	104	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

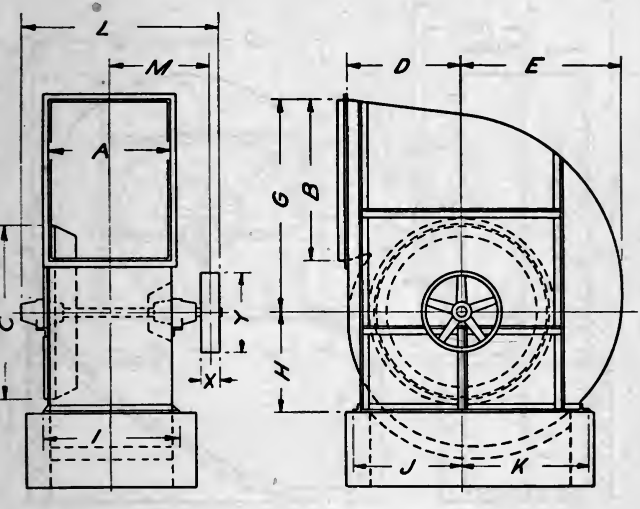


OVERHUNG PULLEY
FULL HOUSING—DOWN DISCHARGE

Dimensions in Inches

Size	A	B	C	E	F	G	H	I	J	K	L	M	X	Y
3	12	15¾	17¼	15⅞	13¼	20 13/16	12	16¼	13¼	22 13/16	27	14½	3	8
3½	14	18⅜	20	18 9/16	15 7/16	24¼	14	18¼	15	26¼	29	15½	3	9
4	16	21	22¾	21 3/16	17⅝	27¾	16	20¼	17	29¾	31	16½	3	10
4½	18	23⅝	25¾	23⅞	19⅞	31¼	18	22¼	18¾	33¼	33	17½	3	11
5	20	26¼	28½	26½	22 1/16	34 11/16	20	24¼	19½	36 11/16	35	18½	3	12
5½	22	28⅞	31½	29⅛	24¼	38 3/16	21½	26¼	21¼	40 3/16	36½	18½	3	14
6	24	31½	34¼	31 13/16	26½	41⅝	23½	28¼	23	43⅝	40	20½	3	16
7	28	36¾	39¾	37⅛	30⅞	48 9/16	27	32¼	26½	50 9/16	47	24	4	18
8	32	42	45½	42⅜	35 5/16	55½	31	36¼	28¾	57½	53	27	5	20
9	36	47¼	51¼	47 11/16	39¾	62 7/16	34½	40¼	31¾	64 7/16	61	31	6	24
10	40	52½	56¾	53	44⅛	69⅜	38½	44¼	34¾	71⅜	65	33	6	26
11	44	57¾	62½	58 5/16	48½	76 5/16	42	49¼	38⅜	78 13/16	73½	37	8	28
12	48	63	68	63⅝	52 15/16	83¼	46	53¼	41⅞	85¾	79½	39½	9	30
13	52	68¼	73½	68⅞	57⅜	90 3/16	49½	58¼	45⅜	93 3/16	83	41½	10	34
14	56	73½	79	74 3/16	61¾	97⅛	53	62¼	47⅜	100⅛	92	46	11	36
15	60	78¾	84¾	79½	66 3/16	104 1/16	57	66¼	51⅜	107 1/16	99	49½	14	38
16	64	84	90¼	84¾	70⅝	111	60½	71¼	54⅞	114½	107	53½		40
17	68	89¼	96	90 1/16	75	117 15/16	64½	76¼	58⅜	121 15/16	112	56		44
18	72	94½	101½	95⅜	79 7/16	124⅞	68	80¼	61⅜	128⅞	120	60		46
19	76	99¾	107	100 11/16	83 13/16	131 13/16	72	84¼	64⅜	135 13/16	125	62½		48
20	80	105	112¾	106	88¼	138¾	75½	88¼	67⅜	142¾	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

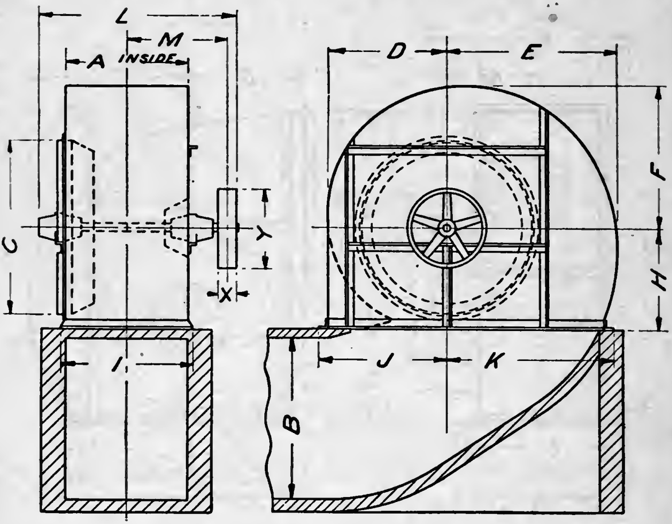


OVERHUNG PULLEY
THREE-QUARTER HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	G	H	I	J	K	L	M	X	Y
6	24	31 1/2	34 1/4	22 5/16	31 13/16	41 5/8	21	28 1/4	23	24 11/16	40	20 1/2	3	16
7	28	36 3/4	39 3/4	26	37 1/8	48 9/16	23 3/4	32 1/4	26 1/2	28 3/4	47	24	4	18
8	32	42	45 1/2	29 3/4	42 3/8	55 1/2	27	36 1/4	28 3/4	32 7/8	53	27	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	62 7/16	30	40 1/4	31 3/4	36 11/16	61	31	6	24
10	40	52 1/2	56 3/4	37 3/16	53	69 3/8	32 3/4	44 1/4	34 3/4	40 7/8	65	33	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16	76 5/16	36	49 1/4	38 3/8	45 1/2	73 1/2	37	8	28
12	48	63	68	44 5/8	63 5/8	83 1/4	38 3/4	53 1/4	41 7/8	49 1/2	79 1/2	39 1/2	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8	90 3/16	42	58 1/4	45 3/8	54 3/16	83	41 1/2	10	34
14	56	73 1/2	79	52 1/16	74 3/16	97 1/8	44 3/4	62 1/4	47 3/8	58 1/4	92	46	11	36
15	60	78 3/4	84 3/4	55 3/4	79 1/2	104 1/16	47 3/4	66 1/4	51 3/8	62 1/8	99	49 1/2	14	38
16	64	84	90 1/4	59 1/2	84 3/4	111	51 1/2	71 1/4	54 7/8	66 3/4	107	53 1/2		40
17	68	89 1/4	96	63 1/4	90 1/16	117 15/16	54 1/4	76 1/4	58 3/8	71 5/16	112	56		44
18	72	94 1/2	101 1/2	66 15/16	95 3/8	124 7/8	57	80 1/4	61 3/8	75 7/16	120	60		46
19	76	99 3/4	107	70 11/16	100 11/16	131 13/16	59 3/4	84 1/4	64 3/8	79 1/2	125	62 1/2		48
20	80	105	112 3/4	74 3/8	106	138 3/4	62 3/4	88 1/4	67 3/8	83 3/8	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

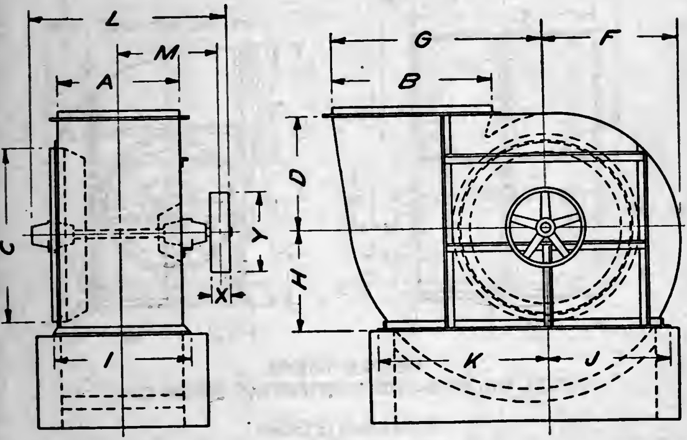


OVERHUNG PULLEY
THREE-QUARTER HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	F	H	I	J	K	L	M	X	Y
6	24	31½	34¼	23⅜	33 11/16	27⅞	21	28¼	25⅜	32⅞	40	20½	3	16
7	28	36¾	39¾	27 5/16	39¼	32 7/16	23¾	32¼	29 5/16	38⅛	47	24	4	18
8	32	42	45½	31 3/16	44 13/16	37⅛	27	36¼	33 3/16	43⅜	53	27	5	20
9	36	47¼	51¼	35 1/16	50 7/16	41¾	30	40¼	37 1/16	48 9/16	61	31	6	24
10	40	52½	56¾	39	56 1/16	46⅜	32¾	44¼	41	53⅞	65	33	6	26
11	44	57¾	62½	42⅞	61 11/16	51	36	49¼	45⅜	59⅝	73½	37	8	28
12	48	63	68	46¾	67 5/16	55 11/16	38¾	53¼	49¼	64⅞	79½	39½	9	30
13	52	68¼	73½	50 11/16	72⅞	60 5/16	42	58¼	53 11/16	70¾	83	41½	10	34
14	56	73½	79	54 9/16	78½	64 15/16	44¾	62¼	57 9/16	75 15/16	92	46	11	36
15	60	78¾	84¾	58 7/16	84 1/16	69 9/16	47¾	66¼	61 7/16	81⅛	99	49½	14	38
16	64	84	90¼	62⅜	89 11/16	74¼	51½	71¼	65⅞	86⅞	107	53½		40
17	68	89¼	96	66¼	95 5/16	78⅞	54¼	76¼	70¼	92 11/16	112	56		44
18	72	94½	101½	70⅛	100 15/16	83½	57	80¼	74⅛	97 15/16	120	60		46
19	76	99¾	107	74 1/16	106½	88⅛	59¾	84¼	78 1/16	103¼	125	62½		48
20	80	105	112¾	77 15/16	112⅛	92 13/16	62¾	88¼	81 15/16	108⅜	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

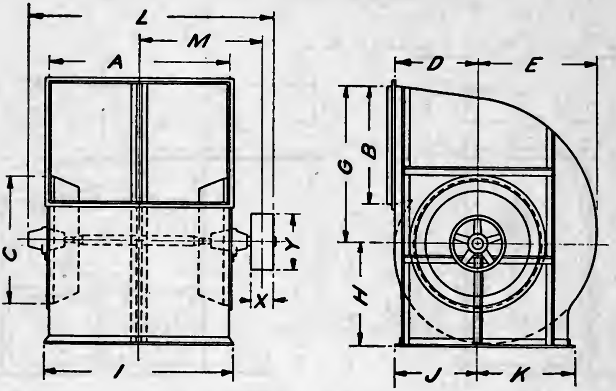


OVERHUNG PULLEY
THREE-QUARTER HOUSING—UP DISCHARGE

Dimensions in Inches

Size	A	B	C	D	F	G	H	I	J	K	L	M	X	Y
6	24	31 1/2	34 1/4	22 5/16	26 1/2	41 5/8	21	28 1/4	23 3/4	33 1/4	40	20 1/2	3	16
7	28	36 3/4	39 3/4	26	30 7/8	48 9/16	23 3/4	32 1/4	27 5/8	38 5/8	47	24	4	18
8	32	42	45 1/2	29 3/4	35 5/16	55 1/2	27	36 1/4	31 1/2	44 1/8	53	27	5	20
9	36	47 1/4	51 1/4	33 1/2	39 3/4	62 7/16	30	40 1/4	35 1/8	49 3/8	61	31	6	24
10	40	52 1/2	56 3/4	37 3/16	44 1/8	69 3/8	32 3/4	44 1/4	39	54 7/8	65	33	6	26
11	44	57 3/4	62 1/2	40 15/16	48 1/2	76 5/16	36	49 1/4	43 5/16	60 3/4	73 1/2	37	8	28
12	48	63	68	44 5/8	52 15/16	83 1/4	38 3/4	53 1/4	47 1/8	66 1/4	79 1/2	39 1/2	9	30
13	52	68 1/4	73 1/2	48 3/8	57 3/8	90 3/16	42	58 1/4	51 1/2	72 1/4	83	41 1/2	10	34
14	56	73 1/2	79	52 1/16	61 3/4	97 1/8	44 3/4	62 1/4	55 1/4	77 5/8	92	46	11	36
15	60	78 3/4	84 3/4	55 3/4	66 3/16	104 1/16	47 3/4	66 1/4	59	82 7/8	99	49 1/2	14	38
16	64	84	90 1/4	59 1/2	70 5/8	111	51 1/2	71 1/4	63 5/16	88 7/8	107	53 1/2		40
17	68	89 1/4	96	63 1/4	75	117 15/16	54 1/4	76 1/4	67 5/8	94 13/16	112	56		44
18	72	94 1/2	101 1/2	66 15/16	79 7/16	124 7/8	57	80 1/4	71 1/2	100 1/4	120	60		46
19	76	99 3/4	107	70 11/16	83 13/16	131 13/16	59 3/4	84 1/4	75 1/4	105 3/4	125	62 1/2		48
20	80	105	112 3/4	74 3/8	88 1/4	138 3/4	62 3/4	88 1/4	79	111	128	64		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

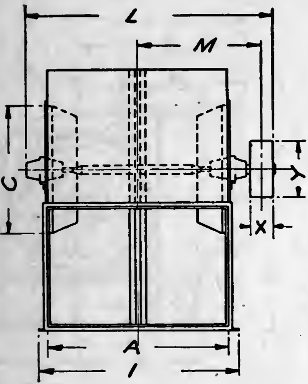


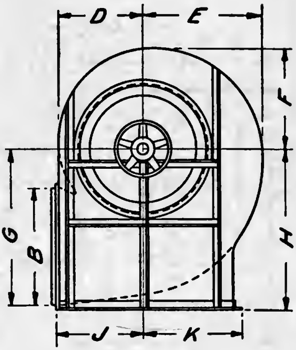
DOUBLE WIDTH
FULL HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	G	H	I	J	K	L	M	X	Y
3	24	15¾	17¼	11 3/16	15⅞	20 13/16	14	28¼	13¼	14	38	19½	3	8
3½	28	18⅜	20	13	18 9/16	24¼	16½	32¼	15	16	44	22½	3	9
4	32	21	22¾	14⅞	21 3/16	27¾	18½	36¼	16⅞	18	48	24½	3	10
4½	36	23⅝	25¾	16¾	23⅞	31¼	21	40¼	18¾	20	55	28	4	11
5	40	26¼	28½	18⅝	26½	34 11/16	23	44¼	19½	22	59	30	4	12
5½	44	28⅞	31½	20 7/16	29⅛	38 3/16	25	48¼	21¼	24	65	33	5	14
6	48	31½	34¼	22 5/16	31 13/16	41⅝	27½	52¼	23	26	69½	35	6	16
7	56	36¾	39¾	26	37⅛	48 9/16	32	60¼	26½	30	77½	39	6	18
8	64	42	45½	29¾	42⅜	55½	36½	68¼	28¾	34	87	43½	8	20
9	72	47¼	51¼	33½	47 11/16	62 7/16	41	76¼	31¾	38	100	50	10	24
10	80	52½	56¾	37 3/16	53	69⅜	45	84¼	34¾	42	110	55	12	26
11	88	57¾	62½	40 15/16	58 5/16	76 5/16	49½	93¼	38⅜	46½	124	62	15	28
12	96	63	68	44⅝	63⅝	83¼	54	101¼	41⅞	50½	137½	69		30
13	104	68¼	73½	48⅜	68⅞	90 3/16	58½	110¼	45⅜	55	146	73		34
14	112	73½	79	52 1/16	74 3/16	97⅛	63	118¼	47⅜	59	158	79		36
15	120	78¾	84¾	55¾	79½	104 1/16	67½	126¼	51⅝	63	166½	83½		38
16	128	84	90¼	59½	84¾	111	72	135¼	54⅞	67½	179	89½		40
17	136	89¼	96	63¼	90 1/16	117 15/16	76	144¼	58⅜	72	187½	94		44
18	144	94½	101½	66 15/16	95⅜	124⅞	80½	152¼	61⅝	76	194	97		46
19	152	99¾	107	70 11/16	100 11/16	131 13/16	85	160¼	64⅜	80	202	101		48
20	160	105	112¾	74⅝	106	138¾	89½	168¼	67⅜	84	212	106		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS



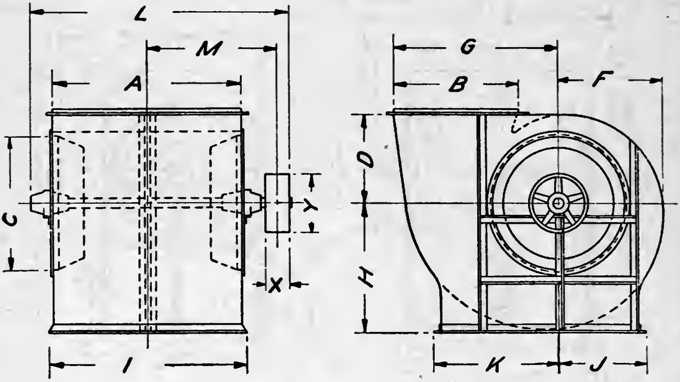


DOUBLE WIDTH
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	24	15¾	17¼	11 3/16	15⅞	13¼	20 13/16	22	28¼	11 3/16	14	38	19½	3	8
3½	28	18⅜	20	13	18 9/16	15 7/16	24¼	25½	32¼	13	16	44	22½	3	9
4	32	21	22¾	14⅞	21 3/16	17⅝	27¾	29	36¼	14⅞	18	48	24½	3	10
4½	36	23⅝	25¾	16¾	23⅞	19⅞	31¼	32½	40¼	16¾	20	55	28	4	11
5	40	26¼	28½	18⅝	26½	22 1/16	34 11/16	36	44¼	18⅝	22	59	30	4	12
5½	44	28⅞	31½	20 7/16	29⅛	24¼	38 3/16	39½	48¼	20 7/16	24	65	33	5	14
6	48	31½	34¼	22 5/16	31 13/16	26½	41⅝	43	52¼	22 5/16	26	69½	35	6	16
7	56	36¾	39¾	26	37⅛	30⅞	48 9/16	50	60¼	26	30	77½	39	6	18
8	64	42	45½	29¾	42⅜	35 5/16	55½	57	68¼	29¾	34	87	43½	8	20
9	72	47¼	51¼	33½	47 11/16	39¾	62 7/16	64	76¼	33½	38	100	50	10	24
10	80	52½	56¾	37 3/16	53	44⅛	69⅜	71	84¼	37 3/16	42	110	55	12	26
11	88	57¾	62½	40 15/16	58 5/16	48½	76 5/16	78	93¼	40 15/16	46½	124	62	15	28
12	96	63	68	44⅝	63⅝	52 15/16	83¼	85	101¼	44⅝	50½	137½	69		30
13	104	68¼	73½	48⅜	68⅞	57⅜	90 3/16	92	110¼	48⅜	55	146	73		34
14	112	73½	79	52 1/16	74 3/16	61¾	97⅛	99	118¼	52 1/16	59	158	79		36
15	120	78¾	84¾	55¾	79½	66 3/16	104 1/16	106	126¼	55¾	63	166½	83½		38
16	128	84	90¼	59½	84¾	70⅝	111	112½	135¼	59½	67½	179	89½		40
17	136	89¼	96	63¼	90 1/16	75	117 15/16	119½	144¼	63¼	72	187½	94		44
18	144	94½	101½	66 15/16	95⅜	79 7/16	124⅞	126½	152¼	66 15/16	76	194	97		46
19	152	99¾	107	70 11/16	100 11/16	83 13/16	131 13/16	133½	160¼	70 11/16	80	202	101		48
20	160	105	112¾	74⅜	106	88¼	138¾	140½	168¼	74⅜	84	212	106		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

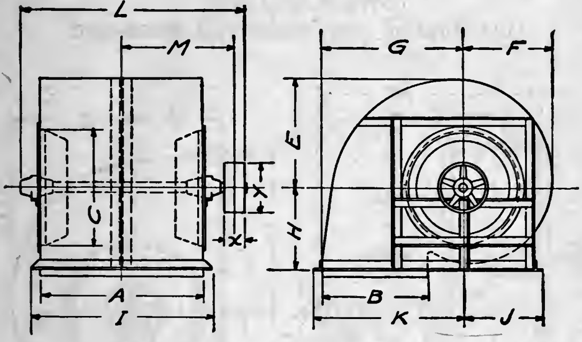


DOUBLE WIDTH
FULL HOUSING—UP DISCHARGE

Dimensions in Inches

Size	A	B	C	D	F	G	H	I	J	K	L	M	X	Y
3	24	15¾	17¼	11 3/16	13¼	20 13/16	17	28¼	13¼	17	38	19½	3	8
3½	28	18⅜	20	13	15 7/16	24¼	19½	32¼	15	19½	44	22½	3	9
4	32	21	22¾	14⅞	17⅝	27¾	22½	36¼	17	22	48	24½	3	10
4½	36	23⅝	25¾	16¾	19⅞	31¼	25	40¼	18¾	24½	55	28	4	11
5	40	26¼	28½	18⅝	22 1/16	34 11/16	27½	44¼	19½	27	59	30	4	12
5½	44	28⅞	31½	20 7/16	24¼	38 3/16	30	48¼	21¼	29½	65	33	5	14
6	48	31½	34¼	22 5/16	26½	41⅝	33	52¼	23	32	69½	35	6	16
7	56	36¾	39¾	26	30⅞	48 9/16	38	60¼	26½	37	77½	39	6	18
8	64	42	45½	29¾	35 5/16	55½	43½	68¼	28¾	42	87	43½	8	20
9	72	47¼	51¼	33½	39¾	62 7/16	49	76¼	31¾	47	100	50	10	24
10	80	52½	56¾	37 3/16	44⅛	69⅜	54	84¼	34¾	52	110	55	12	26
11	88	57¾	62½	40 15/16	48½	76 5/16	59½	93¼	38⅜	57½	124	62	15	28
12	96	63	68	44⅝	52 15/16	83¼	65	101¼	41⅞	62½	137½	69		30
13	104	68¼	73½	48⅜	57⅜	90 3/16	70	110¼	45⅜	68	146	73		34
14	112	73½	79	52 1/16	61¾	97⅛	75½	118¼	47⅜	73	158	79		36
15	120	78¾	84¾	55¾	66 3/16	104 1/16	80½	126¼	51⅜	78	166½	83½		38
16	128	84	90¼	59½	70⅝	111	86	135¼	54⅞	83½	179	89½		40
17	136	89¼	96	63¼	75	117 15/16	91	144¼	58⅜	89	187½	94		44
18	144	94½	101½	66 15/16	79 7/16	124⅞	96½	152¼	61⅜	94	194	97		46
19	152	99¾	107	70 11/16	83 13/16	131 13/16	102	160¼	64⅜	99	202	101		48
20	160	105	112¾	74⅜	88¼	138¾	107	168¼	67⅜	104	212	106		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS



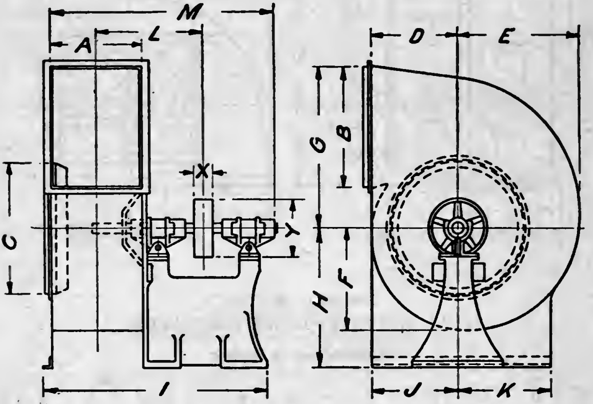
DOUBLE WIDTH
FULL HOUSING—DOWN DISCHARGE

Dimensions in Inches

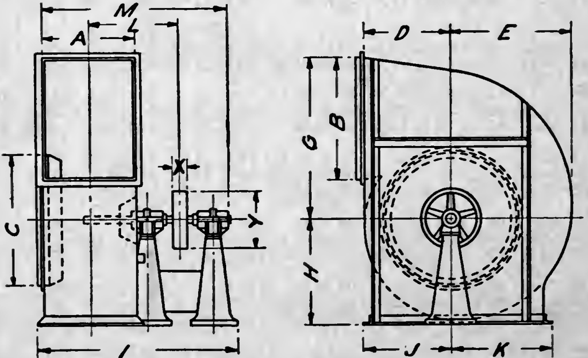
Size	A	B	C	E	F	G	H	I	J	K	L	M	X	Y
3	24	15¾	17¼	15⅞	13¼	20 13/16	12	28¼	13¼	22 13/16	38	19½	3	8
3½	28	18⅜	20	18 9/16	15 7/16	24¼	14	32¼	15	26¼	44	22½	3	9
4	32	21	22¾	21 3/16	17⅝	27¾	16	36¼	17	29¾	48	24½	3	10
4½	36	23⅝	25¾	23⅞	19⅞	31¼	18	40¼	18¾	33¼	55	28	4	11
5	40	26¼	28½	26½	22 1/16	34 11/16	20	44¼	19½	36 11/16	59	30	4	12
5½	44	28⅞	31½	29⅛	24¼	38 3/16	21½	48¼	21¼	40 3/16	65	33	5	14
6	48	31½	34¼	31 13/16	26½	41⅝	23½	52¼	23	43⅝	69½	35	6	16
7	56	36¾	39¾	37⅛	30⅞	48 9/16	27	60¼	26½	50 9/16	77½	39	6	18
8	64	42	45½	42⅜	35 5/16	55½	31	68¼	28¾	57½	87	43½	8	20
9	72	47¼	51¼	47 11/16	39¾	62 7/16	34½	76¼	31¾	64 7/16	100	50	10	24
10	80	52½	56¾	53	44⅛	69⅜	38½	84¼	34¾	71⅜	110	55	12	26
11	88	57¾	62½	58 5/16	48½	76 5/16	42	93¼	38⅜	78 13/16	124	62	15	28
12	96	63	68	63⅝	52 15/16	83¼	46	101¼	41⅞	85¾	137½	69		30
13	104	68¼	73½	68⅞	57⅜	90 3/16	49½	110¼	45⅜	93 3/16	146	73		34
14	112	73½	79	74 3/16	61¾	97⅛	53	118¼	47⅜	100⅛	158	79		36
15	120	78¾	84¾	79½	66 3/16	104 1/16	57	126¼	51⅜	107 1/16	166½	83½		38
16	128	84	90¼	84½	70⅝	111	60½	135¼	54⅞	114½	179	89½		40
17	136	89¼	96	90 1/16	75	117 15/16	64½	144¼	58⅜	121 15/16	187½	94		44
18	144	94½	101½	95⅜	79 7/16	124⅞	68	152¼	61⅜	128⅞	194	97		46
19	152	99¾	107	100 11/16	83 13/16	131 13/16	72	160¼	64⅜	135 13/16	202	101		48
20	160	105	112¾	106	88¼	138¾	75½	168¼	67⅜	142¾	212	106		50

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

OVERHUNG WHEEL
FULL HOUSING—TOP HORIZONTAL DISCHARGE



This Style for No. 3 to No. 6 Fans



This Style for No. 7 to No. 13 Fans

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

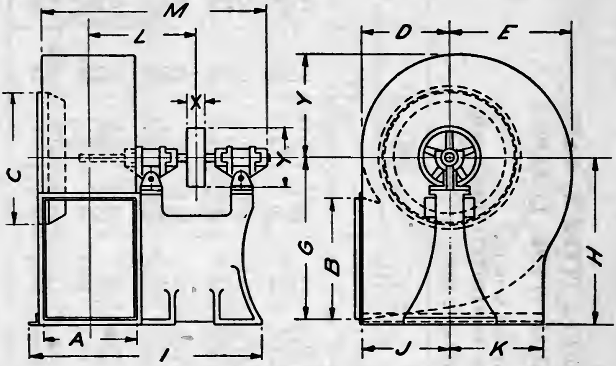
OVERHUNG WHEEL
FULL HOUSING—TOP HORIZONTAL DISCHARGE

Dimensions in Inches

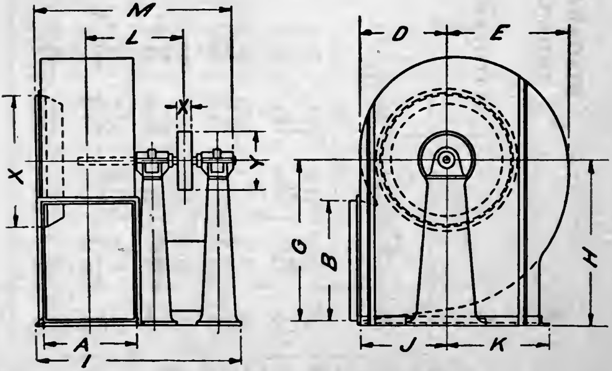
Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	13 1/4	20 13/16	18	32 1/4	11 3/16	12	14 7/8	31 3/8	3	8
3 1/2	14	18 3/8	20	13	18 9/16	15 7/16	24 1/4	20 3/4	36 9/16	13	14	16 3/8	34 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	17 5/8	27 3/4	24	40	14 7/8	16	18 3/8	38 3/4	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	19 7/8	31 1/4	26 5/8	43 3/4	16 3/4	18	20 1/2	43 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	22 1/16	34 11/16	29 1/4	47 5/16	17 1/2	20	22	46 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	24 1/4	38 3/16	32	51 1/4	19 1/4	22	24 1/8	50 3/4	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	26 1/2	41 5/8	35	54 1/4	21	24	25 5/8	53 3/4	3	16
7	28	36 3/4	39 3/4	26	37 1/8		48 9/16	32	60 1/4	26 1/2	30	28 5/8	59 3/4	4	18
8	32	42	45 1/2	29 3/4	42 3/8		55 1/2	36 1/2	64 1/4	28 3/4	34	30 5/8	63 3/4	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16		62 7/16	41	68 1/4	31 3/4	38	32 5/8	67 1/4	6	24
10	40	52 1/2	56 3/4	37 3/16	53		69 3/8	45	85 3/4	34 3/4	42	40 5/8	81 3/4	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16		76 5/16	49 1/2	90 1/4	38 3/8	46 1/2	42 5/8	85 3/8	8	28
12	48	63	68	44 5/8	63 5/8		83 1/4	54	94 1/4	41 7/8	50 1/2	44 5/8	91	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8		90 3/16	58 1/2	98 3/4	45 3/8	55	46 5/8	95	10	34

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

OVERHUNG WHEEL
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE



This Style for No. 3 to No. 6 Fans



This Style for No. 7 to No. 13 Fans

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

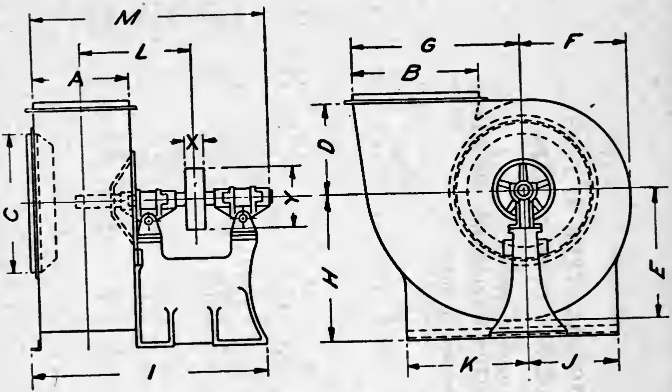
OVERHUNG WHEEL
FULL HOUSING—BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

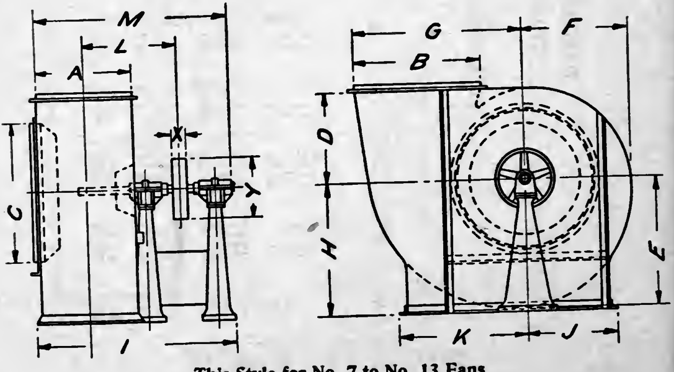
Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	13 1/4	20 13/16	23 3/8	32	11 3/16	12	14 7/8	31 3/8	3	8
3 1/2	14	18 3/8	20	13	18 9/16	15 7/16	24 1/4	27 1/4	36 3/4	13	14	16 3/8	34 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	17 5/8	27 3/4	30 5/8	39 3/4	14 7/8	16	18 3/8	38 3/4	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	19 7/8	31 1/4	34 1/2	43 3/4	16 3/4	18	20 1/2	43 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	22 1/16	34 11/16	38 1/2	48	18 5/8	20	22	46 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	24 1/4	38 3/16	41 7/8	51	20 7/16	22	24 1/8	50 3/4	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	26 1/2	41 5/8	45 3/4	54	22 5/16	24	25 5/8	53 3/4	3	16
7	28	36 3/4	39 3/4	26	37 1/8	30 7/8	48 9/16	50	66 3/4	28	30	31 1/8	64 1/4	4	18
8	32	42	45 1/2	29 3/4	42 3/8	35 5/16	55 1/2	57	70 3/4	31 3/4	34	33 1/8	68 1/4	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	39 3/4	62 7/16	64	77 3/4	35 1/2	38	36 5/8	74 3/4	6	24
10	40	52 1/2	56 3/4	37 3/16	53	44 1/8	69 3/8	71	85 3/4	39 3/16	42	40 5/8	83 3/4	6	26

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

OVERHUNG WHEEL
FULL HOUSING—UP DISCHARGE



This Style for No. 3 to No. 6 Fans



This Style for No. 7 to No. 13 Fans

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

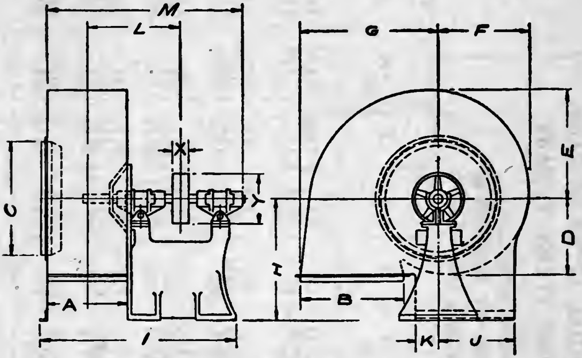
OVERHUNG WHEEL
FULL HOUSING—UP DISCHARGE

Dimensions in Inches

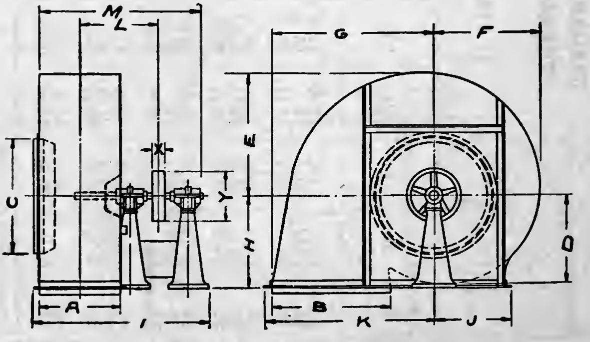
Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	13 1/4	20 13/16	18	32 1/4	11 1/4	15	14 7/8	31 3/8	3	8
3 1/2	14	18 3/8	20	13	18 9/16	15 7/16	24 1/4	20 3/4	36 9/16	13	17 1/2	16 3/8	34 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	17 5/8	27 3/4	24	40	15	20	18 3/8	38 3/4	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	19 7/8	31 1/4	26 5/8	43 3/4	16 3/4	22 1/2	20 1/2	43 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	22 1/16	34 11/16	29 1/4	47 5/16	17 1/2	25	22	46 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	24 1/4	38 3/16	32	51 1/4	19 1/4	27 1/2	24 1/8	50 3/4	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	26 1/2	41 5/8	35	54 1/4	21	30	25 5/8	53 3/4	3	16
7	28	36 3/4	39 3/4	26	37 1/8	30 7/8	48 9/16	38	60 1/4	26 1/2	37	28 5/8	59 3/4	4	18
8	32	42	45 1/2	29 3/4	42 3/8	35 5/16	55 1/2	43 1/2	64 1/4	28 3/4	42	30 5/8	63 3/4	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	39 3/4	62 7/16	49	68 1/4	31 3/4	47	32 5/8	67 1/4	6	24
10	40	52 1/2	56 3/4	37 3/16	53	44 1/8	69 3/8	54	85 3/4	34 3/4	52	40 5/8	81 3/4	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16	48 1/2	76 5/16	59 1/2	90 1/4	38 3/8	57 1/2	42 5/8	85 3/8	8	28
12	48	63	68	44 5/8	63 5/8	52 15/16	83 1/4	65	94 1/4	41 7/8	62 1/2	44 5/8	91	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8	57 3/8	90 3/16	70	98 3/4	45 3/8	68	46 5/8	95	10	34

NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

OVERHUNG WHEEL
FULL HOUSING—DOWN DISCHARGE



This Style for No. 3 to No. 6 Fans



This Style for No. 7 to No. 13 Fans

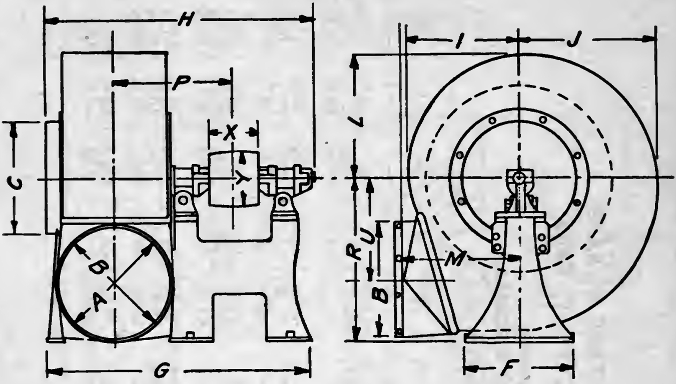
NIAGARA CONOIDAL (TYPE N) FANS
TURBO-CONOIDAL (TYPE T) FANS

OVERHUNG WHEEL
FULL HOUSING—DOWN DISCHARGE

Dimensions in Inches

Size	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y
3	12	15 3/4	17 1/4	11 3/16	15 7/8	13 1/4	20 13/16	18	32 1/4	11 1/4	3	14 7/8	31 3/8	3	8
3 1/2	14	18 3/8	20	13	18 9/16	15 7/16	24 1/4	20 3/4	36 9/16	13	3 3/4	16 3/8	34 1/2	3	9
4	16	21	22 3/4	14 7/8	21 3/16	17 5/8	27 3/4	24	40	15	4 3/4	18 3/8	38 3/4	3	10
4 1/2	18	23 5/8	25 3/4	16 3/4	23 7/8	19 7/8	31 1/4	26 5/8	43 3/4	16 3/4	5 1/2	20 1/2	43 1/2	3	11
5	20	26 1/4	28 1/2	18 5/8	26 1/2	22 1/16	34 11/16	29 1/4	47 5/16	17 1/2	6 1/4	22	46 1/2	3	12
5 1/2	22	28 7/8	31 1/2	20 7/16	29 1/8	24 1/4	38 3/16	32	51 1/4	19 1/4	7 1/4	24 1/8	50 3/4	3	14
6	24	31 1/2	34 1/4	22 5/16	31 13/16	26 1/2	41 5/8	35	54 1/4	21	8	25 5/8	53 3/4	3	16
7	28	36 3/4	39 3/4	26	37 1/8	30 7/8	48 9/16	27	60 1/4	26 1/2	50 1/2	28 5/8	59 3/4	4	18
8	32	42	45 1/2	29 3/4	42 3/8	35 5/16	55 1/2	31	64 1/4	28 3/4	57 1/2	30 5/8	63 3/4	5	20
9	36	47 1/4	51 1/4	33 1/2	47 11/16	39 3/4	62 7/16	34 1/2	68 1/4	31 3/4	64 1/2	32 5/8	67 1/4	6	24
10	40	52 1/2	56 3/4	37 3/16	53	44 1/8	69 3/8	38 1/2	85 3/4	34 3/4	71 3/8	40 5/8	81 3/4	6	26
11	44	57 3/4	62 1/2	40 15/16	58 5/16	48 1/2	76 5/16	42	90 1/4	38 3/8	78 3/4	42 5/8	85 3/8	8	28
12	48	63	68	44 5/8	63 5/8	52 15/16	83 1/4	46	94 1/4	41 7/8	85 3/4	44 5/8	91	9	30
13	52	68 1/4	73 1/2	48 3/8	68 7/8	57 3/8	90 3/16	49 1/2	98 3/4	45 3/8	93 1/4	46 5/8	95	10	34

STANDARD REVERSIBLE PLANING-MILL EXHAUST FANS (TYPE M)

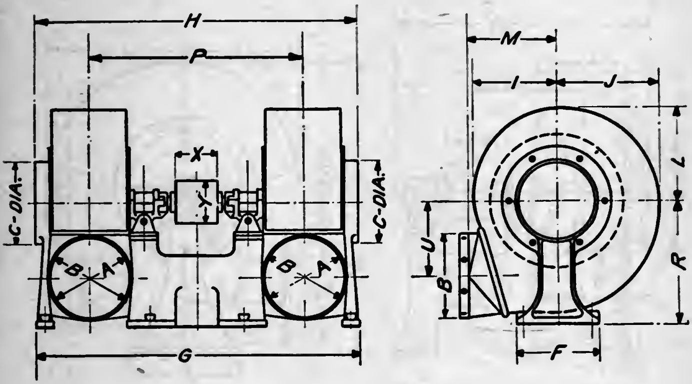


BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	F	G	H	I	J	L	M	P	R	U	X	Y
30	11½	12	12	12	31¾	32⅞	12	15	13½	13	14⅜	18	11	4½	6
35	13½	14	14	13¾	35 9/16	35½	13⅞	17⅜	15⅝	15⅛	15⅝	20¾	12⅞	5½	7
40	15⅜	16	16	15¾	39	39¾	16	20	18	16⅞	17⅜	24	15	6½	8
45	17⅜	18	18	17½	42¾	44½	17⅞	22⅜	20⅛	19¼	19½	26⅝	16⅝	7½	9
50	19⅜	20	20	19¾	46 5/16	47½	19¾	24¾	22¼	21¼	21	29¼	18¼	8½	10
55	21¼	22	22	21¼	50	51½	21⅝	27⅛	24⅜	23	23	32	20⅛	9½	11
60	23¼	24	24	24	52⅜	54	23¾	29¾	26¾	25	24¼	35	22¼	10½	12
70	27¼	28	28	24	60⅝	60½	27½	34½	31	28¾	27¼	39¼	25½	11½	14
80	31¼	32	32	28	67½	65⅝	31½	39½	35½	32½	30½	45½	29½	12½	16

STANDARD REVERSIBLE DOUBLE PLANING-MILL EXHAUST FANS (TYPE M)

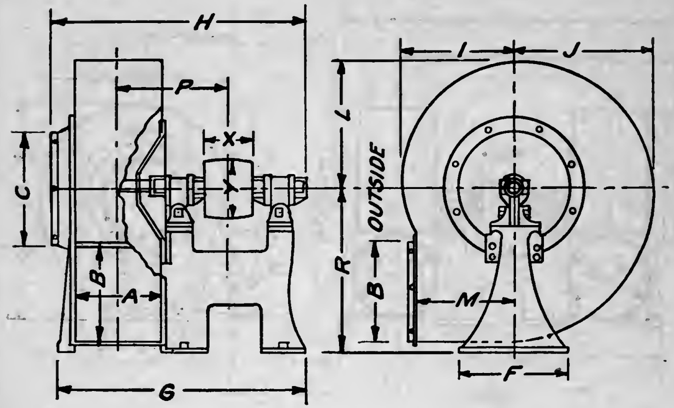


BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	F	G	H	I	J	L	M	P	R	U	X	Y
30	11 ½	12	12	12	48 ⅜	47 ⅛	12	15	13 ½	13	31 ⅛	18	11	6 ½	6
35	13 ½	14	14	13 ¾	53 ¼	52	13 ⅞	17 ⅜	15 ⅝	15 ⅛	34 ½	20 ¾	12 ⅞	7 ½	7
40	15 ⅜	16	16	15 ¾	59 ½	58 ¼	16	20	18	16 ⅞	38 ¼	24	15	8 ½	8
45	17 ⅜	18	18	17 ½	65 ½	64 ¼	17 ⅞	22 ⅜	20 ⅛	19 ¼	42 ¼	26 ⅝	16 ⅝	9 ½	10
50	19 ⅜	20	20	19 ¾	71 ¾	70 ½	19 ¾	24 ¾	22 ¼	21 ¼	46 ½	29 ¼	18 ¼	10 ½	12
55	21 ¼	22	22	21 ¼	77 ⅛	75 ⅜	21 ⅝	27 ⅛	24 ⅜	23	49 ⅞	32	20 ⅛	11 ½	13
60	23 ¼	24	24	24	83 ¼	81 ½	23 ¾	29 ¾	26 ¾	25	54 ½	35	22 ¼	12 ½	14
70	27 ¼	28	28	24	93 ¾	91 ½	27 ½	34 ½	31	28 ¾	60 ½	39 ¼	25 ½	14	16
80	37 ¼	32	32	28	101 ¾	99 ½	31 ½	39 ½	35 ½	32 ½	65 ½	45 ½	29 ½	16	20

SLOW SPEED REVERSIBLE PLANING-MILL EXHAUST FANS (TYPE E)

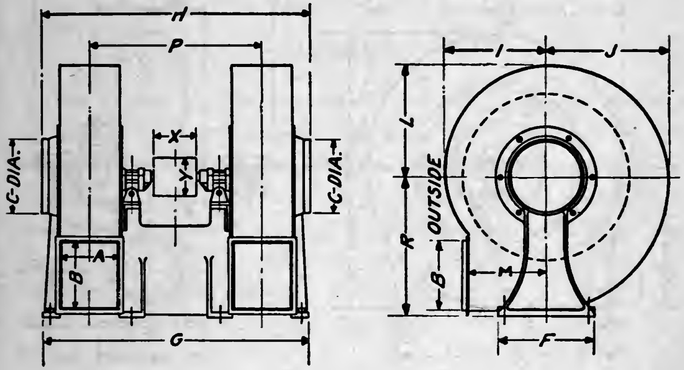


BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	F	G	H	I	J	L	M	P	R	X	Y
30	9⅞	11¾	12½	12	31¼	35	16⅜	20⅜	18⅜	12½	13⅞	23⅜	5	8
35	11½	13⅝	14⅝	13¾	35¼	40¾	19⅛	23⅞	21½	14¼	15⅛	27¼	6	9
40	13⅛	15⅝	16⅝	15¾	38¾	46⅝	21¾	27	24⅜	16¼	17	30⅝	7	10
45	14⅝	17⅝	18⅝	17½	42	52½	24¼	30½	27½	18¼	18⅞	34½	8	11
50	16⅝	19¼	20⅝	19¾	45½	58¼	27⅜	34⅛	30¾	19½	20⅜	38½	9	12
55	18⅛	21⅜	22¾	21¼	49	64	30	37¼	33⅝	22	22¼	41⅞	10	13
60	19⅞	23⅛	24¾	24	51⅞	70	32¾	40¾	36¾	23¾	23⅝	45¾	11	14
70	23	27	28¾	24	60⅜	81½	38⅛	42¾	42¾	27¾	26¼	53½	12	16
80	26½	30¾	32¾	28	66⅝	93¼	43⅝	49	49	31	29¾	61¼	14	20

DOUBLE SLOW SPEED REVERSIBLE PLANING-MILL EXHAUST FANS (TYPE E)

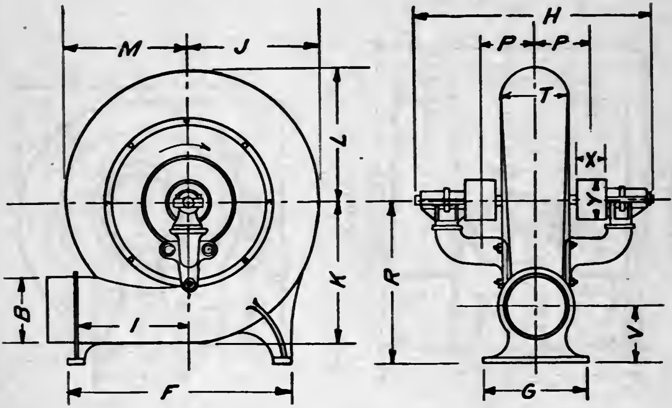


BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

Size	A	B	C	F	G	H	I	J	L	M	P	R	X	Y
30	9 7/8	11 3/4	12 1/2	12	46 3/4	48	16 3/8	20 3/8	18 3/8	12 1/2	30 1/2	23 3/8	7 1/2	8
35	11 1/2	13 5/8	14 5/8	13 3/4	50 1/2	52 1/2	19 1/8	23 7/8	21 1/2	14 1/4	32 3/4	27 1/4	8 1/2	9
40	13 1/8	15 5/8	16 5/8	15 3/4	58	59	21 3/4	27	24 3/8	16 1/4	37 1/2	30 5/8	9 1/2	11
45	14 5/8	17 5/8	18 5/8	17 1/2	64	66	24 1/4	30 1/2	27 1/2	18 1/4	42	34 1/2	10 1/2	12
50	16 5/8	19 1/4	20 5/8	19 3/4	69 1/4	71 3/4	27 3/8	34 1/8	30 3/4	19 1/2	45 1/4	38 1/2	11 1/2	13
55	18 1/8	21 3/8	22 3/4	21 1/4	75 1/2	78 3/4	30	37 1/4	33 5/8	22	49 3/4	41 7/8	12 1/2	14
60	19 7/8	23 1/8	24 3/4	24	81 3/4	85 1/2	32 3/4	40 3/4	36 3/4	23 3/4	54 1/4	45 3/4	15	16
70	23	27	28 3/4	24	93 1/4	98 1/4	38 1/8	47 3/8	42 3/4	27 3/4	62	53 1/2	18	20
80	26 1/2	30 3/4	32 3/4	28	107	113	43 5/8	54 3/8	49	31	72 1/4	61 1/4	22	24

STEEL PRESSURE BLOWERS (TYPE P)



BOTTOM HORIZONTAL DISCHARGE

Dimensions in Inches

No.	B	F	G	H	I	J	K	L	M	P	R	T	V	X	Y
1	3½	8¾	7¾	14¼	4 15/16	5¼	5⅞	5⅛	5 1/16	3½	6⅞	2⅞	2⅞	1⅞	2⅜
2	4	10	7¼	19½	5⅛	6⅜	7⅞	5 5/16	6	3¾	9 3/16	3 5/16	3 5/16	2⅜	2⅞
3	4⅝	15	8⅜	23	8 13/16	8¼	9½	8 5/16	8⅜	4⅝	10¾	4 1/16	3 9/16	2¾	3¼
4	5	17 3/16	10⅞	25¼	10⅛	10⅜	11	9 15/16	9 11/16	5⅛	13½	3 13/16	4 13/16	3⅛	3¾
5	5⅜	18⅜	13⅜	24½	11	11 9/16	12 3/16	11½	10 15/16	4½	14¼	4⅞	4¾	3¼	4
6	6 3/16	21⅝	15¼	27½	12¼	13¼	13 13/16	12⅝	11 13/16	5⅜	16⅝	5½	6	3¾	4½
7	7¼	25	16	34	12½	15⅛	15 11/16	14	13⅝	6¼	19	5¾	7	4⅝	5
8	8 9/16	29⅝	17½	40	15¼	17⅜	18⅛	16⅜	15⅛	8⅝	21⅞	7½	8¼	4¾	6¼
9	10	35⅜	18¾	41½	17⅞	20	20¾	18⅞	17½	9⅜	24¾	9	9	5¼	7¼
10	12⅛	43⅝	20	45	21⅝	25⅝	26 9/16	25½	22½	10⅜	30 9/16	11	10 3/16	5¾	8
11	14⅜	48⅜	23¼	50	23½	30⅞	32⅛	29⅛	27⅜	11⅛	36	11¼	11	6⅜	8½
11½	16¾	57¾	26½	53¼	28¼	35⅞	37⅜	34	32⅛	12¼	41¼	13½	12¼	7	9⅝
12	18	57¾	26½	53¼	28¼	35⅞	37⅜	34	32⅛	12¼	41¼	13½	12¼	9⅛	10

SECTION V

HEATERS

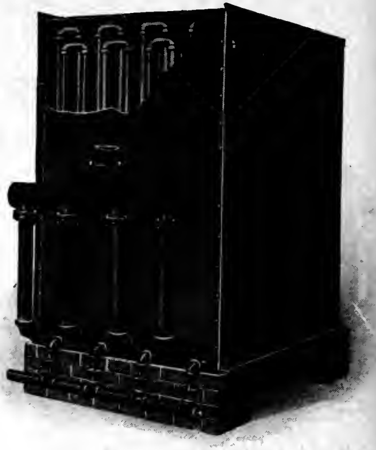
The heaters used in connection with fan systems of heating are usually some form of pipe coil heater like the Buffalo heater or of cast iron like the Vento heater. Either style is made up in sections or units in the direction of the air flow, which makes it possible to assemble a heater of any desired depth. The general arrangement would be the same for either kind of heater, each being enclosed in a sheet-iron case or jacket.

Buffalo Heaters

The Buffalo Standard Pipe Coil Heater is usually one of two styles, the **regular open area pattern** (usually written R. O. A. pattern) or the **return bend pattern** (R. B. pattern). The cuts on page 400 show clearly the difference. Both are made of one-inch full weight steel pipe screwed into a cast-iron base, the pipes being spaced on 2⅝-inch centers. These sections are ordinarily made four rows deep, and are called four-row sections. Detailed dimensions of these heaters will be found on page 451, of the piping connections on pages 452 to 455, and of the sheet-iron casing on page 456. Other special forms of pipe coil heater are also made, such as the mitre coil shown on page 400, or the indirect heater shown on page 459.

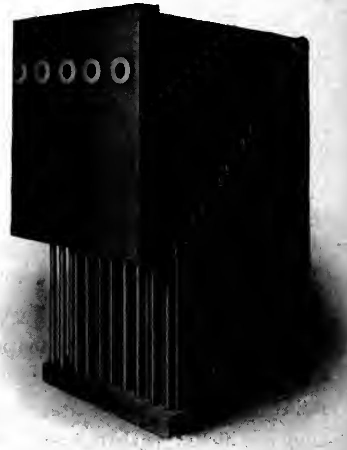
These heaters are usually connected up to steam and drip headers, with separate connections running to each section. In case it may be required to shut off part of the sections during mild weather, both the steam and drip connections to each section are fitted with a valve. Each section should always be fitted with an air vent which should always be thoroughly blown out on turning steam into a section.

Buffalo Regular Open Area Pattern Heater

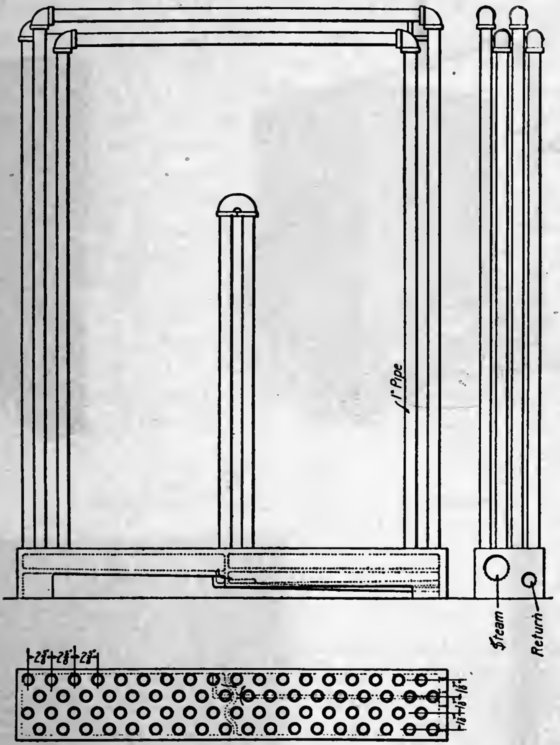


Buffalo Return Bend Heater

Buffalo Four-Row Open Area Pattern Section



Buffalo Miter Coil Heater Without Casing or Connections

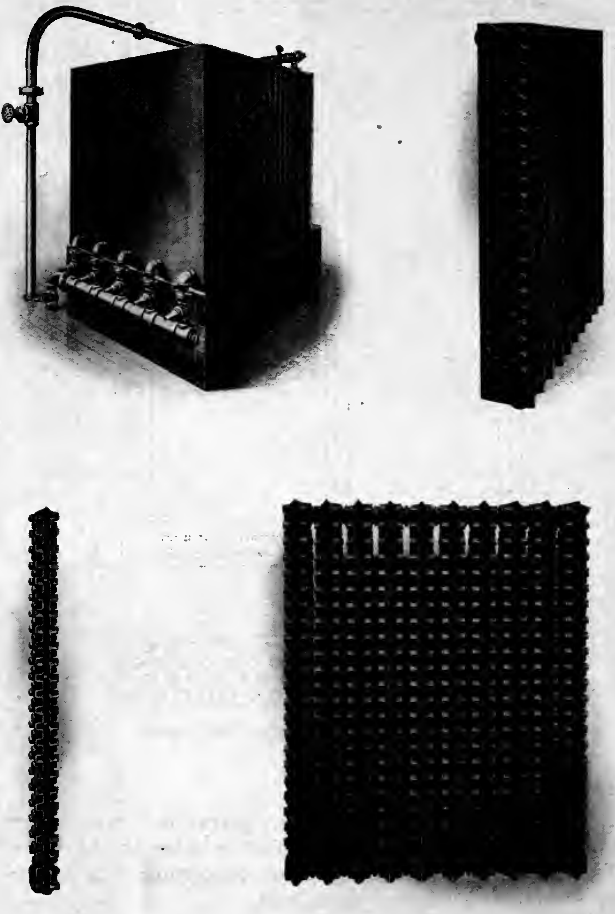


Detail of Buffalo Heater Construction

Vento Heaters

The Vento cast iron heater, an illustration of which is shown on page 402, is designed specially for use in fan and blower work. The tables and data herein given concerning this heater are taken from the catalog of the makers.

These heaters are made in two standard sizes, called the Regular and the Narrow section, and ordinarily either 40, 50 or 60 inches high. The sections may be so mounted as to make a heater of any desired size.



Vento Heaters

Heat Transfer through Metal Surfaces with Forced Circulation

The transfer of heat through metallic tubes, such as a pipe coil heater, from gases and liquids to gases and liquids may be considered of the same nature as already explained for building material in Part II, Section I. That is, there exist three separate operations—the transfer from the warmer fluid to the initial surface of the tube; the heat passage through the tube wall, and the transfer from the secondary tube wall to the cooler fluid. The amount of heat transmitted will depend on the existing conditions such as the nature of the gas or liquid, the arrangement of the surface, the velocity over the heating surface, or to some special conditions.

The total amount of heat transfer per square foot of surface in a given time will depend on the rate of transmission, upon the temperature difference between the two sides of the surface, and to a certain degree upon the absolute temperatures considered. That is, the total heat transmitted per square foot of surface per hour will be

$$H = K(t_s - t)_m \tag{95}$$

where H = total heat transfer in B. t. u. per hour.
K = B. t. u. transmitted per sq. ft. per hour per deg. temp. diff.
$(t_s - t)_m$ = mean temp. diff. between the two sides of the surface.

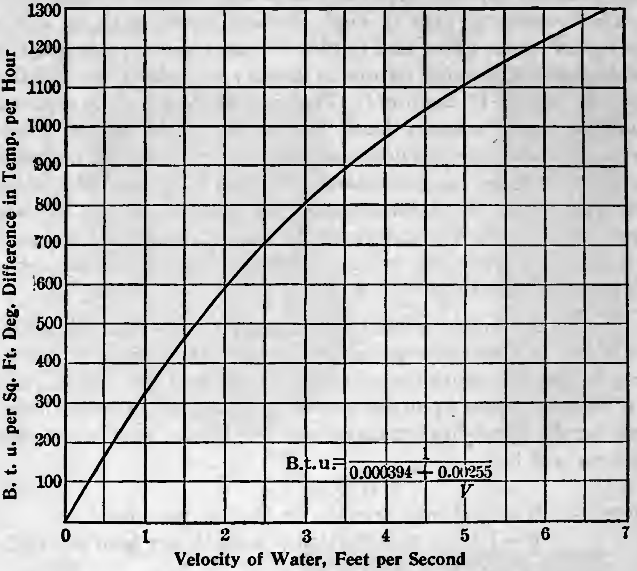
As may be shown the rate of heat conduction between steam and water is approximately, as indicated by the diagram on page 404, based on data obtained from condenser tests. This gives the rate of conductivity from steam to water as

$$K = \frac{1}{0.000394 + \frac{0.00255}{V}} \tag{96}$$

where K = B. t. u. per hour per sq. ft. per deg. temp. diff.
V = velocity in ft. per second.

Condensing coils give a much more rapid rate of conductivity per degree difference in temperature than steam coils, owing to the additional effect of condensation.

The rate of transmission from steam to air under conditions of **longitudinal flow,** based on a series of tests made by the engineering department of the Buffalo Forge Company, is indicated



Heat Transmission from Steam to Water

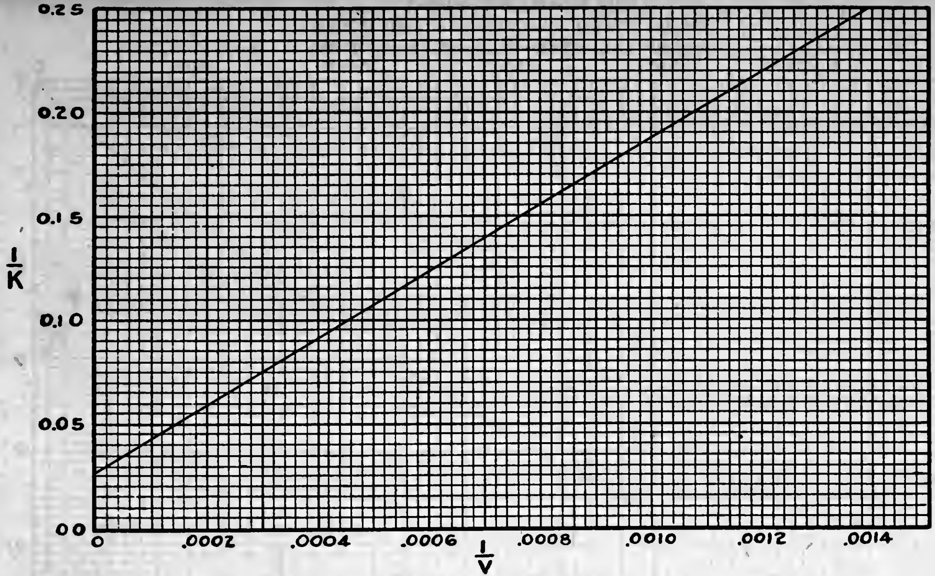
by the diagram on page 406. These tests were conducted on a boiler tube surrounded by steam, and with the air blown through the tube at different velocities. The coefficient of transmission for this condition may be determined from the formula

$$K = \frac{1}{0.026 + \frac{187}{V}} \tag{97}$$

The method of deriving this formula, as well as the one given on page 407 for transverse flow, may be explained by a reference to the diagram on page 405, where the values of $\frac{1}{K}$ and $\frac{1}{V}$ as obtained from the curve drawn through the plotted test points (page 406) are plotted and a straight line drawn through them. The equation of this line is found to be

$$\frac{1}{K} = 0.026 + \frac{187}{V} \tag{98}$$

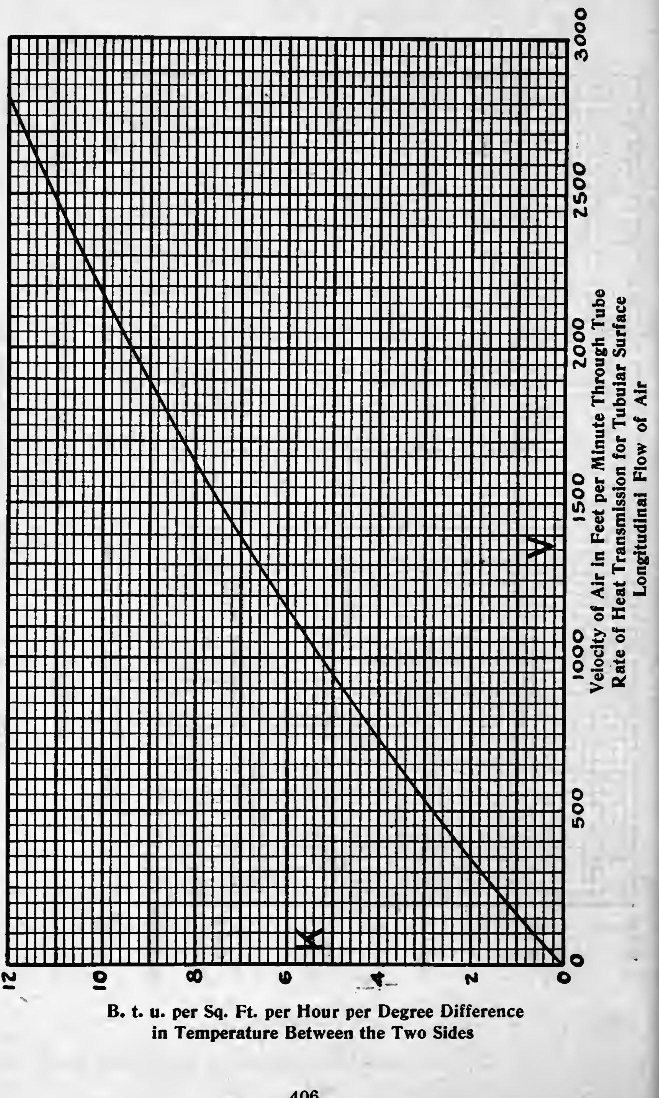
from which we obtain the above equation for K.



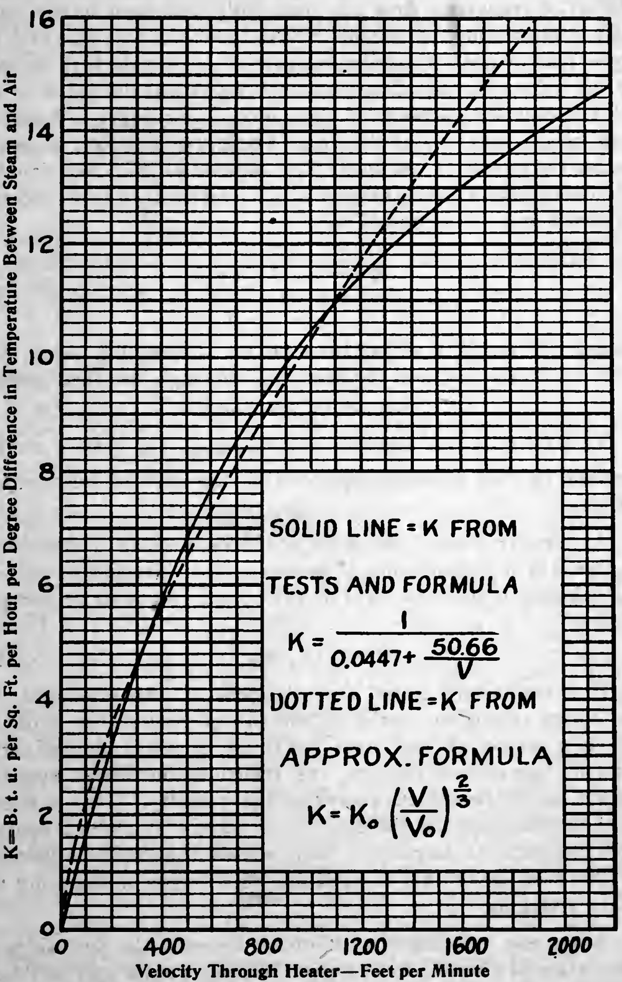
Curve Showing Derivation of Constants in Formula

$$\frac{1}{K}=0.026+\frac{187}{V}$$

Values of K taken from Curve on the Following Page



Rate of Heat Transmission for Tubular Surface
Longitudinal Flow of Air



$$K = \frac{1}{0.0447 + \frac{50.66}{V}}$$

$$K = K_o \left(\frac{V}{V_o}\right)^{\frac{2}{3}}$$

Rate of Heat Transmission for Indirect or Pipe Coil Heater
Transverse Flow of Air

The theory of heat transfer with forced circulation under conditions of transverse flow has been fully discussed in the paper "Air Conditioning Apparatus"* already referred to, in which the coefficient of heat transmission from steam to air with indirect or fan system pipe coil heaters is shown to be as indicated by the solid line of the diagram on page 407. This curve is based on tests made with a Buffalo Forge Company standard pipe coil heater composed of one-inch pipes placed on 2⅝-inch centers. The coefficient K for transverse flow as determined from the data obtained may be expressed as

$$K=\frac{1}{0.0447+\frac{50.66}{V}} \tag{99}$$

where K = B. t. u. per hour per sq. ft. per deg. temp. diff.
V = the velocity of the air through the clear area of the heater in ft. per minute.

This formula was derived by plotting $\frac{1}{K}$ to $\frac{1}{V}$ in a similar manner to that already explained in the case of longitudinal flow.

As already shown, the total heat transmission is dependent on the rate of transmission K, and upon the difference in temperature between the two sides of the conducting wall or surface. That is

$$H=K\ (t_s-t)_m \tag{100}$$

It is frequently stated that the rate of transmission under the above conditions varies as the square root of the velocity, but as a matter of fact, over the range of velocities ordinarily used in fan system heaters, **the transmission varies approximately as the two-thirds power of the velocity.** This is shown by the dotted curve in the diagram on page 407, which is plotted from the formula as given. Thus we see that up to a velocity of 1200 feet per minute there is but slight error in assuming the above relations.

The mean temperature difference between the two sides of the surface of a heater as expressed in this formula may be determined from the formula

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* "Air Conditioning Apparatus," by Willis H. Carrier and Frank L. Busey, Am. Soc. Mech. Engrs., 1911.

$$(t_s - t)_m = \frac{(t_s - t_1) - (t_s - t_2)}{\log_e\left(\frac{t_s - t_1}{t_s - t_2}\right)} \qquad (101)$$

where t_s = temperature of the steam.

t_1 = temperature of the entering air.

t_2 = temperature of the leaving air.

$t_s - t_1$ = entering temp. diff. between the steam and the air.

$t_s - t_2$ = leaving temp. diff. between the steam and the air.

Coefficient of transmission may be found approximately from the formula

$$K = \frac{C_p G}{S} \log_e\left(\frac{t_s - t_1}{t_s - t_2}\right) \qquad (102)$$

where K = B. t. u. per sq. ft. per hour per deg. temp. diff.

C_p = specific heat of air.

G = weight of air in lbs. per hour passed through the heater.

S = total sq. ft. of heating surface.

The amount of heating surface in square feet required may be calculated approximately from the formula

$$S = (0.1119\ Q + 127\ A) \log_{10}\left(\frac{t_s - t_1}{t_s - t_2}\right) \qquad (103)$$

and the temperature rise from

$$\log_{10}\left(\frac{t_s - t_1}{t_s - t_2}\right) = \frac{f}{0.1119\,V + 127} \qquad (104)$$

where S = sq. ft. of heating surface.

A = clear area of heater.

f = ratio total surface to clear area.

Q = cu. ft. of air at 70° F.

V = velocity of the air through the clear area (at 70° F.) in ft. per min.

t_s = steam temperature.

t_1 = entering air temperature.

t_2 = final air temperature.

The derivation of the above formulae may be found in the papers on "Air Conditioning Apparatus" referred to on page 408, and the results obtained, while only approximate, will be found sufficiently accurate for calculations based on the temperatures obtained in heating work with exhaust or low pressure steam. Since the transmission varies slightly with different steam temperatures, for accurate work or for higher steam temperatures it will be found necessary to use the following formula. This is the formula used in the calculation of the heater tables and curves included on pages 418 to 438.

$$f = \left[(0.0001791\ V T_s + 126.8) \log_{10}\left(\frac{t_s - t_1}{t_s - t_2}\right) - \frac{0.000003474\ V^2\ (t_s - t_1)}{0.0447\ V + 50.66}\right] \qquad (105)$$

where T_s = the absolute temperature of the steam.

This same theory of heat transmission has been applied to the Vento Cast Iron Heaters * and the following formula derived as an expression of the coefficient of transmission.

$$K = \frac{1}{0.47 + \frac{61.00}{V}} \qquad (106)$$

While this investigation shows that at the same velocity the heat transmission from pipe coil heaters is greater than from Vento heaters, the frictional resistance is correspondingly greater. But it was also shown that with the same effective velocity, or with the same frictional loss, the rate of transmission was practically the same for the two types of heater.

A further study has been made between pipe coil heaters having one inch pipes on 2¾-inch centers and the Vento Cast Iron Heaters by L. C. Soule.† In discussing the results of his tests the author states: "These results show that former temperature charts published for pipe coils having 2¾-inch centers of pipes read much too high and are, therefore, unsafe to use. These results agree with both the Vento tests and the Buffalo Forge Company tests and by their consistency show their entire reliability." These tests further show that for the same friction the Vento requires 35 per cent. greater velocity than the pipe coil heater on 2¾-inch center, but with the same friction loss the heat transmission was practically the same.

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* "Heat Transmission with Indirect Radiation," by Frank L. Busey, Am. Soc. H. and V. Engrs., 1912.

† "Heat Transmission with Pipe Coils and Cast Iron Heaters under Fan Blast Conditions," Am. Soc. H. and V. Engrs., July, 1913.

Temperatures Attained with Indirect Heaters

While it is true that the total rise in temperature will be greater with a greater depth of heater it is also evident that after air has passed over the first few rows of coils it approaches more nearly the temperature of the steam in the coils, hence the rate of transmission is very much less, and added surface is not of proportionate value. For this reason it is seldom advisable, in heating work, to attempt to raise the temperature of the air above 135° or 140°. For special work such as drying, where higher temperatures are required, it is customary to use high pressure steam in the coils.

In case the system is used for ventilation only, and the heat loss is cared for by direct radiation, the temperature of the air leaving the heater should be from 10° to 15° above that of the room, depending on the drop of temperature in the ducts between the heater and outlets. The temperature of the air leaving the outlet should be within a few degrees of that of the room.

The ratio of the temperature difference between the steam and leaving air to the temperature difference between the steam and entering air is approximately constant for a given depth of heater and a given air velocity through the clear area. That is

$$\frac{t_s - t_2}{t_s - t_1} = \text{approximately a constant.}$$

Condensation in Coils

The weight of steam condensed in the heating coils may be determined either from the B. t. u. as given in the heater tables, or from the cubic feet of air handled and the temperature rise. The heater tables give the B. t. u. per hour per lineal foot of pipe for any given conditions. This, multiplied by the total number of lineal feet in the heater and divided by the latent heat of the steam at the pressure used will give the condensation in pounds per hour.

The weight of steam condensed per hour may also be found by means of the formula

$$C = \frac{\text{Cu. ft. air per min.} \times \text{temp. rise} \times 60}{\text{Cu. ft. air per deg. per B. t. u.} \times \text{latent heat of steam}}$$

For ordinary conditions with dry air at 70° F., it has been shown on page 56 that one B. t. u. will raise the temperature of 55.2 cu. ft. of air one degree, hence we have

$$C = \frac{Q \times (t_2 - t_1) \times 60}{55.2\ L} = 1.087 \frac{Q\ (t_2 - t_1)}{L} \quad (107)$$

where C = lbs. of steam per hour.
Q = cu. ft. air per min.
t_1 = temperature air entering heater.
t_2 = temperature air leaving heater.
L = latent heat of steam (= 960.6 at 5 lbs. press.)

Velocity of Air Through Heaters

The proper velocity for the air through the clear area of the heater will vary with the different conditions such as pressure carried and character of the installation. The following table of velocities is based on the assumption that the pressure loss through the heater should not exceed 50 per cent. of the total pressure on the fan.

MAXIMUM ALLOWABLE VELOCITIES OF AIR THROUGH CLEAR AREA OF HEATER FOR VARIOUS FAN PRESSURES AND FOR VARIOUS DEPTHS OF HEATER

Total Fan Pressure in Inches

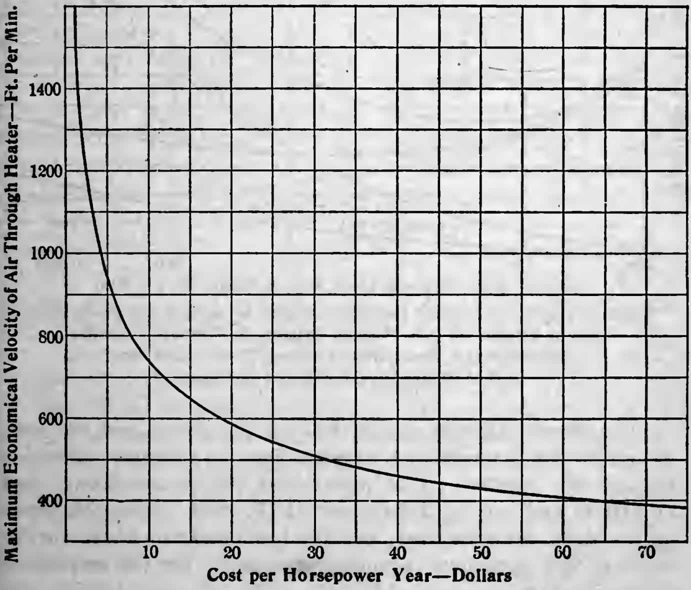
No. of Sect. Deep	¾	1	1¼	1½	1¾	2	2½
4	990	1140	1280	1400	1510	1610	1800
5	885	1020	1140	1250	1350	1440	1610
6	810	930	1040	1140	1230	1320	1470
7	745	860	960	1055	1140	1220	1360
8	700	810	910	995	1070	1150	1280

The velocities here given are intended merely to indicate the practical limit, and except where the ducts are very short it will be found advisable to keep below this. This is especially true in the case of public buildings, where the limit should not exceed 90 per cent. of the above. The table on page 413 gives the maximum velocities advisable both for public buildings and for industrial plants for the different depths of heater indicated. These are based on the average pressures usually carried in such installations.

MAXIMUM VELOCITY ADVISABLE THROUGH HEATER FOR DIFFERENT INSTALLATIONS

Depth of Heater in Sections	In Public Buildings	In Industrial Plants
4	1140	1500
5	1020	1350
6	930	1230
7	860	1140
8	810	1070

The subject of velocity of air through the heater with reference to the cost of power has been discussed in a paper* presented before the A. S. H. & V. Engineers, two of the curves and



Maximum Economical Velocity for Different Costs of Power Allowing 25 Per Cent. on Cost of Heater for Interest and Depreciation, Space, Rental, Etc.

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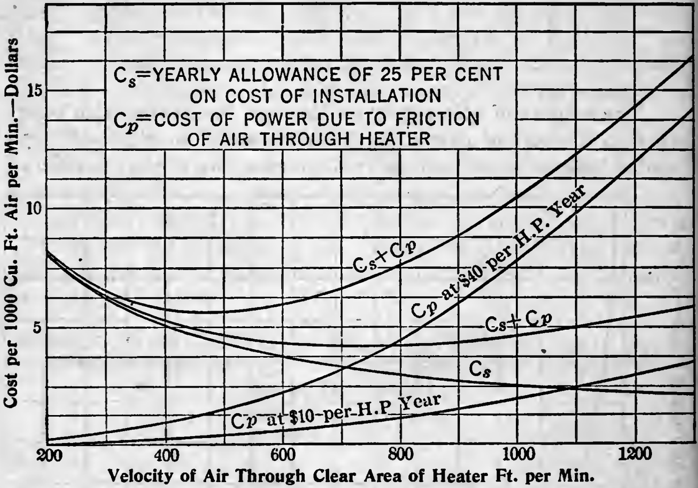
* "The design of Indirect Heating Systems with Respect to Maximum Economy of Maintenance and Operation." Am. Soc. H. & V. Engrs., Jan., 1913, by F. L. Busey and W. H. Carrier.

some of the more important deductions being here reproduced. These diagrams are drawn on the assumption that an allowance of 25 per cent. on the cost of the heater be made to cover interest, depreciation, space, rental, etc. The curve shown on page 413 indicates the maximum velocity allowable under the above assumption for various costs of power.



Relative Yearly Interest and Depreciation Cost of Surface and Power Cost Due to Friction of Air Through Heater at Various Velocities Through the Clear Area, Allowing 25 Per Cent. on Cost of Heater for Interest and Depreciation

The above diagram shows the cost for power and the cost allowance for interest and depreciation at different velocities through the heaters. Two power cost curves are shown, one at $10.00 and one at $40.00 per H. P. year. The combined curves show the total cost, and the low points on these curves indicate the maximum economical velocity for the respective costs of power.

It was shown that the cost of surface varies as the two-thirds power and the cost of power as the seven-thirds power of the velocity. Also that the maximum economical velocity is equal to 0.66 times the assumed velocity multiplied by the ratio of the yearly cost allowed for interest and depreciation to the yearly cost of power, to the one-third power. The following deduction was then made regarding the velocity through the heater.

"As regards the heater, the most economical point will be reached when the installation is so proportioned that the yearly cost of power due to the frictional resistance of the heater amounts to 28.6 per cent. of the annual interest and depreciation allowance on the first cost of the heater. This is true regardless of variations in the depth of heater, temperature rise or steam pressure."

Application of the Heater Tables and Curves

Two sets of heater tables will be found on the following pages, one to be used in connection with Buffalo Standard Heaters and the other with Vento Cast Iron Heaters. The methods here described for the use of the Buffalo heater tables are equally applicable to the Vento tables. The values given for the Buffalo heaters are based on data obtained by W. H. Carrier from an extensive series of tests made for the Buffalo Forge Company. The method of making these tests and of working up the data therefrom has been fully described in the paper* "Air Conditioning Apparatus" already referred to. Large diagrams similar to the charts on pages 432 to 438 were drawn and the values for the heater tables determined.

The heater tables on pages 418 to 431 are computed for various steam pressures and give the final temperature of the air and the B. t. u. transmitted per lineal foot of pipe per hour for different entering temperatures and velocities of the entering air. These results are given for different depths of heater, varying from one to eight four-row sections.

The curves showing the relation between the heater surface and air temperature are useful for obtaining the final temperatures when the entering temperature or velocity is different from that given in the tables. As an example, we will assume a steam pressure of five pounds, an entering temperature of plus 20°, a velocity of 1000 feet per minute through the clear area of the heater which is five sections deep. Starting from the left side of the diagram at 20°, follow to the right to the intersection of the 1000 velocity curve, and then downward to the base line at 2.05 sections: adding to this the five sections which we have

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* "Air Conditioning Apparatus," by W. H. Carrier and F. L. Busey, Am. Soc. Mech. Engrs., Dec., 1911.

assumed for the depth of the heater gives 2.05 + 5.00 = 7.05 sections. Passing upward from the point 7.05 to the 1000 velocity curve and then to the left side of the chart again gives a final or leaving temperature of 113°.

In case the entering and leaving temperatures are assumed to be 0° and 140° respectively, the steam pressure five pounds, and the velocity 800 feet per minute determine how many sections of heater will be required. Passing from the left side of the diagram at 0° to the intersection of the 800 velocity curve and then downward to the base line we find a point of 1.2 sections. In the same way from the 140° point we intersect the base line at 8.6 sections. Then the difference, or 8.6 − 1.2 = 7.4 sections, will be the number of 4 row sections or seven 4 row and one 2 row sections, making 30 rows of pipe deep.

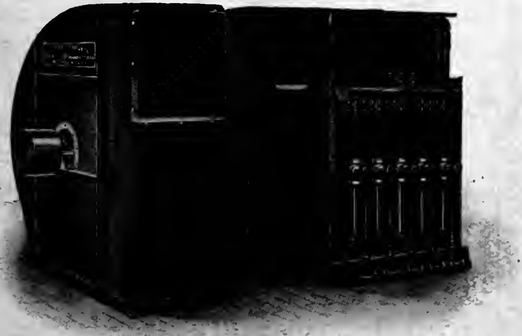
The lower graduations on the base line are for use with other than the Buffalo Standard Heaters, where the value of the ratio **f** is known. In the case of the Buffalo Standard Heater, the value of **f** for a single four-row section is 12.335. That is, there are 12.335 sq. ft. of heating surface in each section to each square foot of clear area. But in the case of other than the standard heater where the pipes are on different centers the value of **f** will be different. As an example we will assume that on measuring up the surface in a pipe coil heater it is found that the total square feet of surface is 1000 and the clear area for the passage of air is 25 sq. ft. This gives a ratio of surface to clear area of **f** = 40. Assuming the air enters the heater at 15° above zero with a velocity of 900 ft. per minute find from the diagram on page 433 for five pound pressure what will be the final temperature of this air. Passing from 15° on the left edge of the chart to half way between the 800 and 1000 velocity curves and then to the bottom line, we find a value of **f** = 20. Adding to this the value of **f** as found from the heater measurements, gives a total of **f** = 20 + 40 = 60. Passing vertically from **f** = 60 on the bottom scale to a point corresponding to 900 velocity and thence to the left edge of the diagram gives a final air temperature of 83°.

These curves may be used in connection with any heater when the ratio of surface to clear area is known. In the case of pipe coil heaters composed of one inch pipes the value of **f** per row of pipes deep is a fixed quantity for each distance between centers of the pipes in the heater. The values of **f** for different spacings are given in the following table for heaters one row deep. From this we may see that with the standard Buffalo heater having centers of 2⅝ inches the value of f per single row of pipes is 3.084 and for a four-row section f is 12.335.

VALUES OF f PER SINGLE ROW OF PIPE ON DIFFERENT CENTERS

C=Pipe Centers in Inches Spacing of 1″ Steel Pipe	$f=\frac{S_1}{A}$ Per Row of 1″ Pipe
2⅛	6.164
2¼	5.041
2⅜	4.214
2½	3.581
2⅝	3.084
2¾	2.688

The scale at the top of the diagrams applies to Vento regular sections on five-inch centers, and is used in the same manner as explained for the standard Buffalo pipe coil heaters.



Planoidal (Type L) Fan Drawing Through Heater

0 lbs.

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 0 LBS., STEAM TEMP. 212° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
-20°	1	20.6	246	16.0	436	12.4	590	9.7	720	7.5	834	5.5	925	3.9	1015
	2	53.3	222	45.8	399	39.8	544	35.2	670	31.3	778	27.8	870	25.0	955
	3	80.9	204	71.1	368	63.1	504	57.3	625	51.9	727	47.5	819	43.5	899
	4	103.4	187	92.6	342	83.6	471	76.3	584	70.1	683	64.8	771	60.3	852
	5	122.0	172	110.9	318	101.1	441	93.2	549	86.3	645	80.4	731	75.0	807
	6	137.7	159	126.0	295	116.3	413	108.0	517	100.5	609	94.1	692	88.4	767
	7	150.7	148	138.9	275	129.3	388	120.6	487	113.1	577	106.4	657	100.5	731
	8	161.3	137	150.2	258	140.4	365	131.8	460	124.1	546	117.4	625	111.3	697
-10°	1	28.4	233	24.5	418	20.7	559	18.1	682	16.3	797	14.1	874	12.6	959
	2	59.8	212	52.9	382	46.7	516	42.4	636	38.7	738	35.4	826	32.5	902
	3	86.1	194	77.0	352	69.5	482	63.5	594	58.7	694	54.0	776	50.5	856
	4	108.0	179	97.6	326	88.9	450	81.9	557	76.0	652	70.6	733	66.4	811
	5	126.0	165	115.0	303	105.7	421	98.0	524	91.7	617	85.9	698	80.9	772
	6	140.6	152	129.6	282	120.1	395	112.1	494	105.1	582	99.0	661	93.8	734
	7	153.2	141	142.0	263	132.8	371	124.4	466	116.9	550	110.6	627	105.0	697
	8	163.3	131	152.8	247	143.4	349	135.0	440	127.8	522	121.0	596	115.4	665
0°	1	36.9	224	33.0	400	29.4	535	27.0	655	24.9	755	23.0	835	21.5	913
	2	66.8	203	60.0	364	54.0	491	50.0	607	46.2	700	43.3	788	40.5	860
	3	91.8	186	83.0	336	75.8	460	70.1	567	65.4	661	61.2	742	57.6	815
	4	112.8	171	102.8	312	94.3	429	87.6	531	82.0	622	77.0	700	72.9	774
	5	129.9	158	119.4	290	110.6	403	103.2	501	96.7	586	91.6	667	86.7	736
	6	144.0	146	133.2	269	124.3	377	116.5	471	109.7	554	104.0	631	98.8	699
	7	155.9	135	145.2	252	136.3	354	128.2	444	121.0	524	114.9	597	109.8	656
	8	165.5	126	155.5	236	146.2	333	138.4	420	131.5	498	124.9	568	119.6	635

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 0 LBS., STEAM TEMP. 212° F.

0 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	44.6	210	41.0	376	37.7	504	35.4	616	33.4	709	31.7	787	30.1	853
	2	73.5	193	67.2	347	61.5	469	57.4	575	53.6	661	51.0	746	48.1	809
	3	97.5	177	89.2	320	82.0	437	76.7	539	71.8	625	68.0	704	64.5	771
	4	117.3	163	107.9	297	99.9	409	93.4	506	87.9	591	83.1	665	79.2	734
	5	133.5	150	123.6	276	115.1	382	108.1	476	102.0	558	96.9	632	92.1	697
	6	147.1	139	136.9	257	128.4	359	120.9	448	114.0	526	108.7	599	103.6	662
	7	158.6	129	148.4	240	139.8	337	132.0	423	125.0	498	119.2	568	114.2	632
	8	167.5	119	158.1	225	149.3	317	141.7	399	134.9	473	128.8	540	123.5	602
20°	1	52.8	199	49.0	351	46.0	473	44.0	582	42.0	667	40.4	740	39.0	807
	2	80.2	183	74.0	328	69.0	446	65.0	546	61.4	628	58.7	704	56.2	768
	3	103.1	168	95.0	303	88.3	414	83.1	510	78.6	592	74.8	665	71.7	732
	4	122.0	155	112.8	281	105.3	388	99.1	480	93.8	559	89.5	632	85.6	696
	5	137.3	142	127.6	261	119.9	364	113.0	451	107.0	528	102.1	598	97.8	661
	6	150.4	132	140.4	243	132.5	341	125.2	425	118.8	500	113.4	566	108.9	629
	7	161.2	122	151.5	228	143.1	320	135.8	401	129.4	474	123.7	539	118.9	600
	8	169.8	114	160.7	213	152.2	301	144.9	379	138.7	450	132.6	512	127.6	571
60°	1	86.1	158	83.0	279	80.8	378	78.9	458	77.2	522	76.0	581	75.0	637
	2	108.0	146	103.0	261	98.7	352	95.3	428	92.7	496	90.5	555	88.5	605
	3	126.0	133	119.3	240	114.2	329	109.8	403	106.0	465	103.0	522	100.4	572
	4	140.7	122	133.0	221	127.5	307	122.1	377	117.8	438	114.2	493	111.2	543
	5	153.3	113	145.3	207	139.1	288	133.4	356	128.5	415	124.2	467	121.0	518
	6	163.5	105	155.7	194	148.8	270	143.0	336	138.0	394	133.3	445	129.6	492
	7	171.4	97	164.0	180	157.1	252	151.4	317	146.1	373	141.3	423	137.2	468
	8	177.8	89	171.1	168	164.7	238	158.8	300	153.4	354	148.8	404	144.4	449

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 5 LBS., STEAM TEMP. 227° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
−20°	1	23.0	261	17.9	459	14.1	620	11.1	754	8.9	876	6.9	976	5.1	1065
	2	58.0	236	49.5	421	43.1	574	38.0	703	34.1	820	30.2	913	27.2	1001
	3	87.1	216	76.5	390	68.4	536	61.5	659	56.1	769	51.1	862	46.9	946
	4	111.0	198	99.3	362	90.0	500	82.1	619	75.5	724	69.8	817	64.6	898
	5	131.2	183	118.4	336	108.5	467	100.0	582	92.7	683	86.1	772	80.6	854
	6	147.9	169	135.2	314	124.6	438	115.6	548	108.0	647	100.8	732	94.9	813
	7	161.5	157	149.0	293	138.5	412	129.3	517	121.3	612	114.0	696	107.8	775
	8	172.7	146	160.7	274	150.3	387	141.0	488	133.0	580	125.7	662	119.1	738
−10°	1	31.1	249	26.0	436	22.5	591	20.0	728	17.7	839	15.3	918	13.8	1010
	2	64.6	226	56.3	402	50.3	553	45.5	673	41.5	781	37.8	869	34.9	953
	3	92.6	207	82.4	374	74.8	514	68.1	631	62.8	736	57.8	822	53.9	904
	4	115.4	190	104.0	346	95.4	479	87.8	593	81.4	693	75.5	778	70.9	858
	5	135.0	176	122.7	322	113.0	447	105.0	558	97.9	654	91.4	738	86.1	816
	6	151.0	163	138.9	301	128.6	420	120.1	526	112.4	618	105.7	701	99.9	777
	7	164.0	151	152.0	281	141.9	395	133.0	495	125.2	585	118.3	667	112.3	741
	8	174.7	140	163.2	262	153.3	371	144.4	468	136.4	555	129.5	634	123.0	705
0°	1	39.5	239	34.5	418	31.1	565	28.5	691	26.4	800	24.2	878	22.6	959
	2	71.5	217	63.5	385	58.0	527	53.0	643	49.3	747	45.6	829	42.9	910
	3	98.2	198	88.4	357	81.0	491	74.6	603	69.5	702	65.0	788	61.0	863
	4	120.2	182	109.2	331	100.8	458	93.5	567	87.2	661	81.8	744	77.2	819
	5	138.9	168	127.3	309	117.9	429	110.0	534	103.0	624	97.0	706	91.9	780
	6	154.1	156	142.4	288	132.7	402	124.3	502	117.0	591	110.6	670	105.0	748
	7	166.6	144	155.0	268	145.4	378	136.8	474	129.2	559	122.6	637	116.7	708
	8	177.0	134	166.0	251	156.3	355	147.7	448	140.0	530	133.2	605	127.1	674

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 5 LBS., STEAM TEMP. 227° F.

5 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	47.6	228	43.0	400	39.5	537	37.1	657	35.0	758	33.1	838	31.5	913
	2	78.3	207	71.0	370	65.3	503	60.8	616	56.8	710	53.5	791	50.9	868
	3	103.7	189	94.5	342	87.4	469	81.2	576	76.2	669	71.9	751	68.0	821
	4	124.8	174	114.4	317	106.3	438	99.2	541	93.1	630	88.0	710	83.7	782
	5	142.7	161	131.7	295	122.7	410	115.0	509	108.3	596	102.6	674	97.7	745
	6	157.3	149	146.1	275	136.7	384	128.8	480	121.6	564	115.6	640	110.1	708
	7	169.2	138	158.8	258	148.9	361	140.5	452	133.2	534	127.0	608	121.2	674
	8	179.1	128	168.7	241	159.3	340	151.0	428	143.8	507	137.0	578	131.1	643
20°	1	55.6	216	51.5	382	48.3	515	45.8	626	43.6	716	41.9	795	40.4	866
	2	85.1	197	78.0	352	72.7	479	68.3	586	64.4	673	61.5	755	58.8	823
	3	109.4	181	100.5	326	94.0	449	88.0	550	82.8	635	79.0	716	75.3	783
	4	129.6	166	119.6	302	111.6	417	104.9	515	99.1	600	94.1	674	90.0	743
	5	146.7	154	135.6	280	127.4	391	120.0	485	113.4	566	108.1	641	103.4	708
	6	160.3	142	149.8	262	140.8	366	133.0	457	126.0	536	120.5	610	115.2	674
	7	171.8	132	161.2	245	152.4	344	144.4	431	137.3	508	131.4	579	125.9	642
	8	181.2	122	171.3	229	162.3	324	154.5	408	147.1	482	141.0	550	135.4	612
60°	1	88.6	173	85.4	308	82.9	417	80.5	497	79.0	576	77.6	639	76.3	692
	2	112.2	158	106.8	284	102.3	385	98.7	469	95.5	538	93.0	600	91.0	658
	3	132.2	146	125.0	263	119.0	358	114.4	440	110.4	509	107.0	570	104.2	625
	4	148.6	134	140.5	244	133.7	335	128.2	414	123.4	481	119.4	540	116.0	594
	5	162.0	124	153.2	226	146.1	313	140.1	389	134.8	454	130.4	512	126.4	564
	6	173.1	114	164.4	211	157.0	294	150.6	366	145.2	430	140.1	486	135.9	537
	7	182.4	106	174.0	198	166.5	277	160.0	347	154.2	408	149.0	463	144.6	513
	8	190.0	99	182.0	185	174.7	261	168.0	327	162.2	387	157.2	442	152.7	492

20 lbs.

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 20 LBS., STEAM TEMP. 258.8° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
–20°	1	27.6	289	22.1	510	17.5	682	14.5	837	11.8	964	9.5	1070	7.6	1172
	2	67.2	264	57.9	473	50.1	638	44.5	782	40.0	910	35.9	1017	32.1	1105
	3	100.0	243	88.0	437	78.4	597	70.6	733	64.5	854	59.0	958	54.4	1053
	4	127.1	223	113.4	405	102.6	558	93.5	688	86.3	806	79.7	907	74.0	998
	5	149.7	206	135.3	377	123.2	521	113.5	648	105.5	761	98.1	860	91.8	949
	6	168.3	190	153.7	351	141.4	489	131.4	612	122.3	719	114.4	815	107.5	902
	7	183.7	177	169.4	328	157.0	460	146.8	578	137.3	681	129.1	775	121.9	861
	8	196.5	164	182.5	307	170.4	433	160.0	546	150.5	646	142.0	737	134.7	821
–10°	1	35.5	276	30.4	489	25.7	650	23.0	800	20.7	931	18.0	1016	16.2	1112
	2	74.0	255	65.0	455	57.5	614	52.0	752	47.6	873	43.5	973	40.0	1061
	3	105.4	234	94.0	421	84.4	573	77.3	706	71.5	824	66.0	922	61.5	1012
	4	131.8	215	118.5	390	108.0	537	99.1	662	92.2	775	85.8	872	80.3	958
	5	153.5	198	139.5	363	128.0	502	118.6	624	110.6	731	103.5	826	97.4	912
	6	171.5	184	157.2	338	145.2	471	135.8	589	126.9	692	119.3	784	112.5	867
	7	186.3	170	172.2	316	160.5	443	150.6	557	141.4	656	133.4	745	126.4	827
	8	198.7	158	185.0	296	173.3	417	163.3	525	154.4	623	145.9	709	138.8	790
0°	1	44.0	267	39.1	474	34.6	630	31.9	774	29.8	904	27.1	983	25.2	1070
	2	80.9	245	72.2	438	65.1	592	59.7	724	55.5	841	51.5	937	48.3	1025
	3	111.2	225	100.0	404	91.3	554	83.8	678	78.4	792	73.0	885	68.6	971
	4	136.5	207	123.9	376	113.4	516	105.0	637	98.4	746	92.0	837	86.9	922
	5	157.4	191	143.9	349	132.6	483	123.8	601	116.0	704	108.9	793	103.0	875
	6	174.8	177	161.0	326	149.6	454	140.3	567	131.7	666	124.2	753	117.9	834
	7	189.1	164	175.5	304	164.3	427	154.5	535	145.6	631	138.0	717	131.0	795
	8	200.5	152	187.8	285	176.6	402	166.7	505	158.1	599	149.9	682	143.0	759

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 20 LBS., STEAM TEMP. 258.8° F.

20 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	52.3	257	47.5	454	43.5	610	40.7	745	38.3	858	36.3	954	34.2	1027
	2	87.8	236	79.1	419	72.8	571	67.3	695	63.1	805	59.5	901	56.4	985
	3	116.9	216	106.0	388	97.7	532	90.4	650	85.0	758	80.0	849	75.8	931
	4	141.1	199	128.9	361	119.0	496	110.8	611	104.1	713	98.4	804	93.3	884
	5	161.3	184	148.1	335	137.7	465	129.0	577	121.1	674	114.6	761	109.0	841
	6	178.0	170	164.7	313	153.9	436	144.6	544	136.2	638	129.3	724	123.1	800
	7	191.9	158	178.6	292	167.6	410	158.3	514	149.9	606	142.3	688	136.0	764
	8	203.1	146	190.4	274	179.7	386	170.1	485	161.9	576	153.9	654	147.3	729
20°	1	60.9	248	56.2	439	52.4	590	49.5	716	47.4	831	45.1	911	43.3	989
	2	94.7	227	86.1	401	80.4	549	75.0	667	71.0	773	67.5	864	64.5	944
	3	122.8	208	112.0	372	104.0	509	97.0	623	91.9	727	87.0	813	83.0	892
	4	146.0	191	134.1	346	124.5	475	116.7	586	110.3	685	104.5	769	99.8	847
	5	165.3	176	152.7	322	142.5	446	134.3	555	126.7	647	120.2	729	114.9	806
	6	181.1	163	168.5	300	158.0	418	149.1	522	141.0	612	134.2	693	128.3	766
	7	194.5	151	181.8	280	171.3	393	162.0	492	154.1	581	146.6	658	140.6	731
	8	205.0	140	193.1	262	182.9	370	173.8	466	165.7	552	158.0	628	151.6	698
60°	1	94.0	206	89.6	359	86.8	488	84.1	585	82.4	679	80.4	740	79.1	811
	2	122.0	188	114.9	333	109.8	453	105.1	547	101.9	635	98.8	706	96.0	764
	3	145.5	173	136.4	309	129.4	421	124.0	518	119.0	596	115.0	667	111.1	723
	4	164.9	159	154.6	287	146.8	395	140.4	488	134.4	564	129.6	633	125.4	694
	5	181.0	147	170.1	267	161.7	370	154.6	459	148.0	534	142.5	600	138.0	662
	6	194.0	135	183.1	249	174.5	347	166.9	432	160.4	507	154.0	570	149.1	630
	7	205.1	126	194.5	233	185.5	326	177.9	409	171.1	481	164.8	545	159.3	602
	8	214.0	117	204.0	218	195.0	307	187.3	386	180.4	456	174.1	519	168.4	575

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

GAUGE PRESSURE 40 LBS., STEAM TEMP. 286.7° F.

40 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
-20°	1	32.5	318	26.0	558	21.0	746	17.5	910	14.8	1055	12.4	1179	10.3	1286
	2	75.6	290	65.0	516	57.0	700	50.4	854	45.0	986	40.7	1104	36.8	1206
	3	111.3	265	97.6	476	87.7	653	78.4	796	72.0	930	66.1	1044	61.0	1146
	4	141.0	244	125.8	442	113.6	608	104.0	752	95.7	877	88.4	985	82.3	1086
	5	166.0	226	149.8	412	136.2	568	125.6	706	116.6	825	108.4	934	101.9	1035
	6	186.3	209	170.0	384	156.0	534	144.8	666	134.8	782	126.2	887	118.9	983
	7	203.3	194	187.0	359	173.1	502	161.4	629	151.0	741	142.3	844	134.4	936
	8	217.9	180	201.7	336	188.0	473	176.0	594	165.8	704	156.6	803	148.4	894
-10°	1	40.0	303	34.2	536	30.0	728	26.4	883	23.0	1001	21.0	1128	18.8	1223
	2	82.0	279	72.2	499	63.8	671	58.0	825	52.8	952	48.3	1061	44.9	1165
	3	116.5	256	104.1	461	93.6	628	85.8	775	78.5	894	73.0	1007	67.8	1101
	4	145.3	236	131.0	428	119.2	588	109.5	725	101.8	848	95.0	955	88.8	1049
	5	169.6	218	154.0	398	141.0	550	130.6	682	121.6	798	113.8	901	107.3	996
	6	189.4	202	173.5	371	159.9	515	149.2	644	139.6	756	131.2	856	123.8	947
	7	205.9	187	190.0	347	176.8	486	165.3	608	155.4	717	146.6	814	139.1	904
	8	219.4	174	204.1	325	191.1	457	179.5	575	169.5	680	160.5	775	152.5	862
0°	1	48.0	291	42.3	513	38.5	701	34.7	842	32.0	970	29.8	1084	27.5	1167
	2	89.5	271	79.0	479	71.7	652	65.5	795	60.5	917	56.3	1024	52.7	1119
	3	122.6	248	109.6	443	100.0	607	92.0	744	85.2	861	79.7	967	75.1	1063
	4	150.5	228	136.0	412	124.6	567	115.2	699	107.7	817	100.8	916	95.2	1010
	5	173.5	210	158.2	384	145.8	531	135.4	657	127.0	770	119.4	869	113.0	960
	6	192.8	195	177.2	358	164.1	498	153.5	621	144.0	728	136.2	826	129.0	913
	7	208.6	181	193.0	334	180.4	468	169.1	586	159.4	691	151.0	785	143.4	870
	8	221.8	168	206.8	314	194.4	442	182.7	554	173.3	657	164.6	749	156.5	830

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

GAUGE PRESSURE 40 LBS., STEAM TEMP. 286.7° F.

40 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	56.5	282	51.1	499	47.2	677	43.5	813	41.0	940	38.5	1041	37.0	1146
	2	95.8	260	86.2	462	79.1	629	72.6	759	68.3	884	64.3	988	60.7	1076
	3	128.2	239	116.0	429	106.4	585	98.8	718	92.2	831	86.6	929	82.1	1020
	4	154.9	220	141.1	398	130.2	547	121.0	673	113.7	786	107.0	882	101.7	970
	5	177.5	203	162.5	370	150.4	511	140.6	634	132.5	770	125.0	837	118.6	922
	6	196.0	188	180.9	346	168.4	480	157.9	598	148.9	702	141.0	795	134.2	879
	7	211.0	174	196.2	323	184.0	452	172.9	565	164.0	667	155.5	756	148.2	838
	8	223.9	162	209.4	302	197.0	425	186.3	535	177.1	633	168.4	720	160.9	801
20°	1	64.8	272	59.5	479	55.4	644	52.3	784	49.5	895	47.2	990	45.7	1091
	2	102.9	251	93.4	445	86.5	605	80.8	737	76.0	849	72.0	940	68.7	1034
	3	133.9	230	122.1	413	112.8	563	105.6	692	99.1	799	93.6	893	89.4	982
	4	159.5	212	146.4	383	135.7	526	126.9	648	119.8	757	113.0	845	107.7	931
	5	181.3	196	167.0	357	155.1	492	145.9	611	137.5	713	130.5	804	124.5	887
	6	199.0	181	184.6	333	172.5	462	162.5	576	153.6	675	146.0	764	139.4	845
	7	213.8	168	199.4	311	187.6	436	176.9	544	168.1	642	160.0	728	152.9	806
	8	226.2	156	212.2	291	200.4	410	189.8	515	181.0	610	172.4	693	165.0	769
60°	1	98.6	234	93.9	411	90.1	548	87.6	670	85.1	767	83.0	842	81.4	914
	2	130.6	214	122.5	379	116.0	509	111.3	622	107.6	722	103.8	797	101.0	870
	3	156.7	196	146.6	350	138.2	474	132.1	583	126.7	674	122.0	752	118.0	821
	4	179.0	180	167.2	325	157.3	443	150.4	548	144.0	637	138.4	713	133.7	782
	5	197.1	166	185.0	303	174.5	416	166.5	517	159.4	603	153.2	678	147.7	745
	6	212.2	154	199.6	281	189.3	392	180.4	487	173.2	572	166.3	645	160.4	710
	7	224.9	143	212.3	264	201.9	369	193.0	461	185.6	544	178.2	615	172.0	679
	8	235.3	133	223.4	248	212.8	348	204.0	436	196.2	516	188.9	586	181.2	643

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

GAUGE PRESSURE 60 LBS., STEAM TEMP. 307.3° F.

60 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
−20°	1	36.0	340	29.0	594	24.2	804	20.3	978	17.0	1122	14.3	1245	12.3	1371
	2	82.0	309	70.0	546	61.6	742	54.6	905	49.1	1048	44.5	1174	40.2	1278
	3	120.0	283	105.0	505	94.1	692	85.0	849	77.6	987	71.2	1106	65.7	1213
	4	151.8	261	134.9	470	122.0	646	111.4	797	102.7	930	95.0	1046	88.8	1155
	5	177.8	240	160.4	438	146.2	605	134.5	750	124.8	878	116.1	991	109.1	1096
	6	199.8	222	182.0	408	167.5	569	155.0	708	144.5	831	135.5	943	127.4	1043
	7	218.2	206	200.2	382	185.5	534	173.0	669	162.0	788	152.4	896	144.1	995
	8	234.0	193	215.9	358	201.2	503	188.4	632	177.4	748	167.3	852	159.0	950
−10°	1	44.2	329	37.7	578	32.6	775	28.9	944	25.6	1079	23.0	1197	21.0	1316
	2	88.9	300	77.4	530	69.0	719	62.2	876	56.8	1013	52.3	1134	48.5	1244
	3	125.5	274	111.4	491	100.3	669	91.4	820	84.1	951	78.0	1067	73.0	1175
	4	156.4	252	140.2	456	127.5	625	117.0	770	108.8	901	101.0	1010	95.0	1114
	5	181.6	232	165.0	425	151.0	586	139.5	725	130.0	849	121.8	959	114.7	1059
	6	203.0	215	185.6	395	171.3	550	159.4	685	149.1	804	140.3	912	132.3	1007
	7	221.0	200	203.5	370	189.0	517	176.9	648	166.1	763	156.6	866	148.8	963
	8	236.3	187	218.6	347	204.4	488	191.8	612	181.0	724	171.3	825	163.0	918
0°	1	52.3	317	45.4	550	41.0	746	37.3	905	34.5	1046	32.0	1161	29.8	1265
	2	95.5	290	84.3	511	76.4	695	69.8	847	64.3	975	60.1	1094	56.4	1197
	3	131.2	265	117.0	473	106.7	647	98.0	793	91.2	922	85.0	1031	79.9	1131
	4	161.0	244	145.3	441	133.0	605	122.7	744	114.6	869	107.2	975	101.4	1076
	5	185.4	225	169.0	410	156.0	568	144.5	701	135.4	821	127.2	926	120.5	1023
	6	206.2	208	189.2	383	175.5	532	164.0	663	154.0	778	145.0	879	137.7	974
	7	224.0	194	206.5	358	192.8	501	180.7	626	170.2	737	161.0	837	153.1	929
	8	239.0	181	221.0	335	207.5	472	195.2	592	184.6	700	175.2	797	167.0	886

60 lbs.

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 60 LBS., STEAM TEMP. 307.3° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	61.0	309	54.0	533	49.5	719	46.0	873	43.1	1004	40.9	1121	38.5	1210
	2	102.3	280	91.5	494	83.5	669	77.1	814	72.4	946	68.0	1055	64.0	1146
	3	137.0	257	123.1	457	112.9	624	104.8	767	98.0	890	91.8	992	87.0	1090
	4	165.9	236	150.5	426	138.5	584	128.7	720	120.6	838	113.5	942	107.5	1035
	5	189.4	218	173.3	396	160.5	548	149.8	678	140.8	793	133.0	895	126.0	985
	6	209.7	202	193.0	370	179.5	514	168.4	640	158.8	752	150.2	850	142.9	940
	7	226.5	188	209.6	346	196.2	484	184.6	605	174.5	713	165.5	808	157.9	897
	8	240.6	175	224.0	324	210.5	456	198.8	572	188.5	676	179.4	770	171.3	856
20°	1	68.7	295	62.6	516	58.1	693	54.6	839	52.0	970	49.7	1078	47.5	1167
	2	109.0	270	99.0	479	91.0	646	85.0	788	80.0	910	75.7	1013	72.0	1104
	3	142.8	248	129.5	443	119.4	603	111.1	737	104.8	857	99.0	958	94.3	1051
	4	170.0	227	155.7	412	144.1	565	134.4	694	126.8	810	119.9	909	114.1	999
	5	193.1	210	178.0	408	165.5	529	154.9	655	146.0	764	138.5	862	132.0	951
	6	212.8	195	197.0	358	183.8	497	172.9	618	163.5	725	155.0	819	148.0	906
	7	229.3	181	213.0	334	200.0	468	188.3	583	178.7	688	170.1	780	162.7	865
	8	242.7	169	226.8	314	213.6	440	202.2	552	192.2	653	183.4	743	175.7	826
60°	1	101.7	253	96.5	442	92.5	591	89.7	720	87.0	819	85.0	907	83.1	981
	2	136.5	232	127.7	411	120.8	551	115.3	671	111.0	773	107.2	859	104.1	936
	3	165.3	213	154.0	380	145.2	517	138.0	631	132.0	728	127.2	815	123.0	892
	4	189.0	196	176.7	354	166.4	484	158.0	594	151.0	690	145.0	773	140.0	849
	5	209.4	181	195.6	329	184.8	454	175.8	562	168.0	655	161.0	735	155.4	810
	6	226.3	168	212.0	308	200.5	426	190.8	529	182.7	620	175.2	699	169.1	772
	7	240.5	156	226.7	289	214.3	401	204.5	501	195.9	589	188.2	666	181.5	737
	8	252.1	146	238.5	271	226.4	378	216.4	474	207.5	559	199.9	636	193.0	706

80 lbs.

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

GAUGE PRESSURE 80 LBS., STEAM TEMP. 323.7° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
-20°	1	38.5	355	31.5	625	26.5	846	22.2	1024	19.0	1182	16.0	1310	13.7	1431
	2	86.6	323	74.5	574	65.7	780	58.3	950	52.2	1095	47.8	1234	43.6	1350
	3	126.5	296	111.3	531	99.7	726	90.0	890	82.2	1033	75.5	1158	70.0	1274
	4	160.0	273	142.3	492	128.5	676	117.6	835	108.2	972	100.4	1095	93.8	1208
	5	187.5	252	169.0	459	154.0	633	142.0	786	131.5	919	122.6	1038	115.0	1146
	6	210.3	233	191.7	428	176.4	596	163.1	740	152.0	869	142.4	985	134.3	1092
	7	229.8	216	210.8	400	195.3	560	182.0	700	170.5	825	160.3	937	151.5	1040
	8	245.4	201	227.2	375	211.7	527	198.3	662	186.6	783	176.0	891	166.8	991
-10°	1	47.0	346	40.0	607	34.6	812	30.6	985	27.5	1137	25.0	1274	22.6	1384
	2	93.8	315	82.0	559	73.0	755	65.9	921	60.0	1061	55.2	1186	51.5	1305
	3	132.5	288	117.5	516	105.8	702	96.5	861	88.9	1000	82.3	1120	77.2	1234
	4	165.0	265	147.3	477	133.5	653	123.2	808	114.1	941	106.4	1059	100.0	1167
	5	191.5	244	173.2	445	158.9	615	146.9	761	136.8	890	128.0	1004	120.7	1110
	6	214.0	226	195.4	415	180.1	576	167.5	718	156.6	842	147.3	954	139.5	1058
	7	232.6	210	214.1	388	198.8	543	185.8	679	174.5	799	164.7	908	156.0	1007
	8	247.8	195	230.0	364	215.0	512	201.6	642	190.1	758	180,0	864	171.0	960
0°	1	55.0	334	48.4	587	43.0	782	39.6	961	36.2	1098	33.9	1233	31.9	1354
	2	100.6	305	89.0	541	80.3	731	73.0	885	67.8	1028	63.0	1146	59.6	1265
	3	138.0	279	123.3	499	112.0	679	103.1	834	95.9	969	89.5	1086	84.3	1193
	4	169.5	257	152.5	462	139.4	634	129.0	782	120.2	911	112.8	1026	106.4	1129
	5	195.5	237	178.0	432	163.6	595	151.9	737	142.0	861	133.6	972	126.5	1074
	6	217.0	219	199.0	402	184.5	559	172.0	695	161.5	816	152.2	923	144.4	1022
	7	235.1	204	217.1	376	202.4	526	189.5	657	178.9	775	169.2	880	160.8	975
	8	250.0	190	232.6	353	218.0	496	205.0	622	194.0	735	184.0	837	175.2	930

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

GAUGE PRESSURE 80 LBS., STEAM TEMP. 323.7° F.

80 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	63.2	323	56.8	568	52.2	768	48.2	927	44.9	1058	42.4	1179	40.5	1295
	2	107.5	296	96.4	525	88.0	710	81.0	861	75.5	993	71.0	1110	67.3	1216
	3	143.8	271	129.6	484	118.5	658	110.0	809	102.4	934	96.3	1047	91.2	1149
	4	174.3	249	158.0	449	145.1	615	135.0	758	126.0	879	118.9	991	112.7	1090
	5	199.5	230	182.4	418	168.5	577	157.0	713	147.5	834	139.0	939	132.2	1038
	6	220.4	213	202.8	390	188.7	542	176.5	673	166.0	788	157.0	892	149.5	987
	7	238.0	198	220.5	365	206.0	510	193.7	637	182.9	749	173.4	849	165.4	943
	8	252.0	183	235.0	341	221.0	480	208.5	602	197.6	711	188.0	810	179.5	899
20°	1	71.2	311	65.0	546	60.0	728	56.5	885	54.0	1031	51.5	1146	49.1	1235
	2	114.5	287	103.3	506	95.0	682	88.3	828	83.1	957	78.9	1072	75.0	1167
	3	149.4	262	135.4	467	124.3	633	116.2	778	109.1	901	103.0	1007	98.0	1104
	4	178.8	241	163.0	434	150.5	594	140.5	731	132.1	850	125.0	955	119.0	1051
	5	203.4	223	186.8	405	173.2	558	162.1	690	152.8	805	144.6	907	137.8	1002
	6	223.4	206	206.5	377	192.5	523	181.0	651	171.0	763	162.0	861	154.5	952
	7	240.5	191	223.4	352	209.5	493	197.5	615	187.0	723	178.0	821	170.0	910
	8	254.3	178	238.0	331	224.0	464	211.9	582	201.4	688	192.0	782	184.5	873
60°	1	104.5	270	99.3	477	95.0	637	91.3	759	89.0	879	86.7	972	84.9	1057
	2	141.6	248	132.0	437	124.4	586	119.0	716	114.1	820	110.5	919	107.0	998
	3	172.0	226	160.0	404	150.2	547	143.0	671	136.8	776	131.4	866	126.9	947
	4	198.0	209	184.0	376	173.0	514	164.1	631	156.5	732	150.0	819	145.0	902
	5	219.0	193	204.3	350	192.4	482	182.8	596	174.4	694	167.4	782	161.0	858
	6	237.0	179	221.5	327	209.3	453	199.0	562	190.1	658	182.4	742	175.5	817
	7	251.2	166	236.5	306	224.0	426	213.4	532	204.0	624	196.0	707	189.0	782
	8	263.3	154	249.0	287	236.9	403	226.0	503	216.6	594	208.3	675	200.8	747

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS

100 lbs.

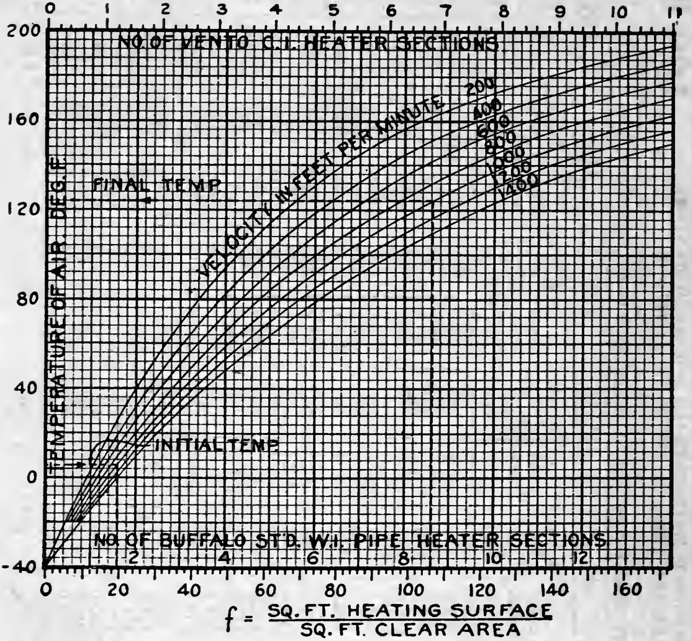
GAUGE PRESSURE 100 LBS., STEAM TEMP. 337.6° F.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
-20°	1	40.7	368	33.3	646	28.0	873	23.3	1050	20.2	1219	17.0	1344	14.5	1465
	2	91.0	337	78.1	595	68.4	804	61.0	982	55.0	1137	49.6	1266	45.4	1388
	3	132.1	308	116.0	550	103.5	749	93.8	920	85.4	1065	78.4	1194	72.8	1313
	4	166.7	283	148.0	509	134.0	700	122.5	864	112.8	1007	104.4	1132	97.0	1242
	5	195.6	262	176.0	476	160.3	656	147.4	812	137.0	952	127.4	1073	119.6	1185
	6	219.4	242	199.6	444	183.4	617	169.5	766	158.0	900	147.9	1018	139.5	1128
	7	239.0	224	219.7	415	203.1	580	189.2	725	177.2	854	166.7	971	157.2	1075
	8	256.0	209	236.5	389	219.7	545	206.0	685	194.0	811	183.3	925	173.3	1026
-10°	1	48.5	355	41.5	625	36.1	839	32.0	1019	29.0	1182	26.0	1306	23.3	1414
	2	97.5	326	85.0	576	75.6	779	68.5	952	62.4	1098	57.4	1226	53.2	1341
	3	137.8	299	121.8	533	110.0	728	100.1	890	92.0	1031	85.2	1155	79.8	1271
	4	171.3	275	153.0	494	139.3	679	128.0	837	118.6	975	110.6	1097	103.5	1205
	5	199.5	254	180.3	462	165.0	637	152.5	788	142.0	922	133.0	1041	125.2	1148
	6	222.3	235	203.0	431	187.3	598	174.0	744	162.8	873	152.8	987	144.4	1092
	7	241.8	218	222.7	403	206.7	563	193.0	703	181.0	827	171.0	941	161.8	1042
	8	258.2	203	239.2	378	223.3	531	209.5	665	197.5	786	187.4	898	177.6	995
0°	1	56.6	343	50.0	606	44.6	811	40.4	980	37.5	1137	34.5	1252	32.0	1358
	2	104.4	317	92.5	561	83.0	755	75.8	919	70.2	1064	65.2	1186	61.0	1295
	3	143.0	289	128.0	518	116.0	704	106.6	862	99.0	1001	92.5	1122	86.7	1227
	4	176.0	267	158.3	480	144.7	658	133.7	811	124.6	945	116.8	1063	110.0	1167
	5	203.1	246	184.8	448	169.9	618	157.2	763	147.2	893	138.5	1008	131.0	1112
	6	225.5	228	206.9	418	191.5	581	178.5	722	167.4	846	157.8	957	149.8	1060
	7	244.5	212	226.0	392	210.2	546	197.0	683	185.5	804	175.6	913	166.5	1010
	8	260.7	198	242.0	367	226.4	515	212.9	645	201.3	763	191.4	870	181.8	965

TEMPERATURE OBTAINED WITH BUFFALO STANDARD HEATERS
GAUGE PRESSURE 100 LBS., STEAM TEMP. 337.6° F.

100 lbs.

Temp. of Entering Air	No. of Heater Sections	Velocity of Air in Ft. per Min., Measured at 70° F. and 29.92 Inches Barometer													
		200		400		600		800		1000		1200		1400	
		Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour	Final Temp.	B. t. u. per Lin. Ft. per Hour
10°	1	65.0	334	58.2	585	53.1	784	49.3	953	46.5	1107	43.5	1216	41.5	1337
	2	111.1	307	99.5	543	90.4	731	83.5	892	78.3	1036	73.4	1154	69.1	1254
	3	149.0	281	133.7	500	122.5	682	113.3	835	105.7	967	99.3	1083	94.0	1189
	4	181.0	259	163.5	466	150.5	639	139.5	785	130.8	916	123.0	1028	116.5	1130
	5	207.3	239	189.3	435	174.6	599	162.5	740	153.0	867	144.0	975	136.7	1076
	6	228.8	221	209.5	403	195.5	563	183.0	699	172.4	821	162.8	927	154.8	1024
	7	247.3	206	228.3	378	214.0	530	200.8	661	189.7	778	180.1	884	171.2	978
	8	262.8	192	244.9	356	229.8	500	216.5	626	205.1	739	195.5	844	186.0	934
20°	1	73.4	324	66.8	568	61.6	755	58.0	922	54.8	1055	52.0	1161	50.1	1278
	2	118.3	298	106.6	525	97.9	709	91.2	864	85.5	993	80.8	1106	77.0	1210
	3	154.9	273	140.0	485	128.5	658	120.0	809	112.4	934	106.3	1047	101.0	1146
	4	185.7	251	169.0	452	155.8	618	145.1	759	136.6	884	129.0	992	123.0	1093
	5	211.1	232	193.6	421	179.4	580	167.8	717	158.0	837	149.6	943	142.5	1041
	6	232.0	214	214.3	393	199.7	545	187.5	677	177.0	793	168.0	898	160.0	991
	7	250.0	199	232.3	368	217.5	513	204.8	640	194.0	754	184.7	856	176.0	946
	8	265.0	186	247.5	345	232.8	484	220.0	606	209.0	716	199.4	816	190.3	904
60°	1	107.0	285	101.3	501	96.5	664	92.8	796	90.0	910	88.0	1016	86.2	1112
	2	145.6	260	135.2	456	127.6	615	121.5	746	116.6	858	112.5	955	109.0	1040
	3	178.0	239	164.8	424	154.8	575	146.8	702	140.1	810	134.9	909	130.0	991
	4	205.0	220	190.4	395	178.5	539	169.0	661	161.0	766	154.4	859	148.9	944
	5	227.0	203	211.6	368	199.0	506	188.6	624	180.0	728	172.6	819	165.9	899
	6	245.5	188	229.9	344	216.7	475	205.5	588	196.2	688	188.8	781	181.0	856
	7	261.6	175	245.5	321	232.0	447	221.0	558	211.0	654	203.0	743	195.0	819
	8	274.3	162	258.8	301	245.7	422	234.3	528	224.4	623	215.8	709	207.7	784

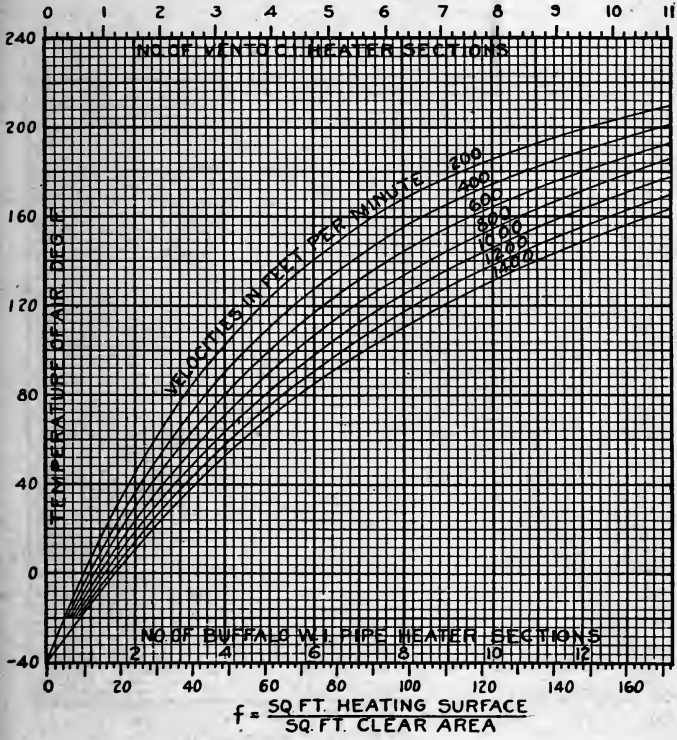


Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 0 Lbs.

Temperature, 212° F.

Application of Heater Curves. For example, the air enters the heating coils at 5 deg. above zero, with a velocity through the clear area of 1000 ft. per min. What will be the final air temperature with a Buffalo standard pipe coil heater, seven sections deep? Follow dotted line from + 5 deg. to 1.6 sections on bottom edge. Adding 7 sections gives 8.6 sections. Following



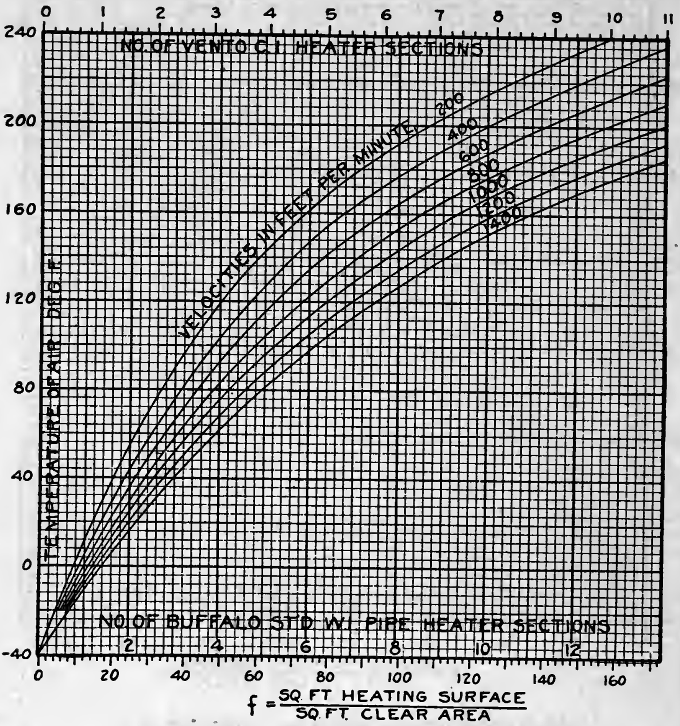
Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 5 Lbs.

Temperature, 227° F.

dotted line upward to 1000 velocity curve and to left edge gives final temperature of 124 deg. Reverse this process where the depth of heater is required for a given temperature rise.

For more complete directions see "Application of Heater Tables and Curves" on page 415.

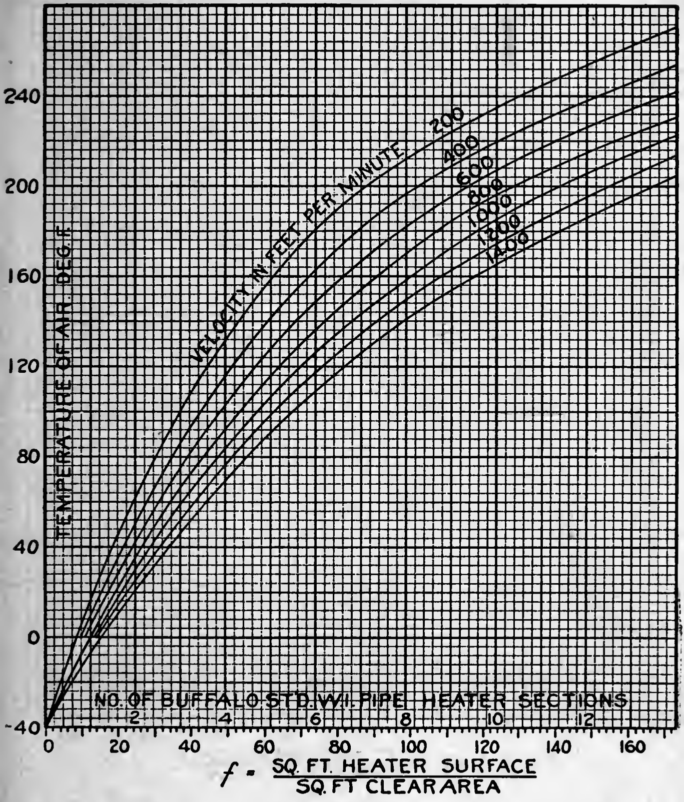


Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE **20 Lbs.**

Temperature, 258.8° F.

For Explanation of Curves, see pages 415 and 432

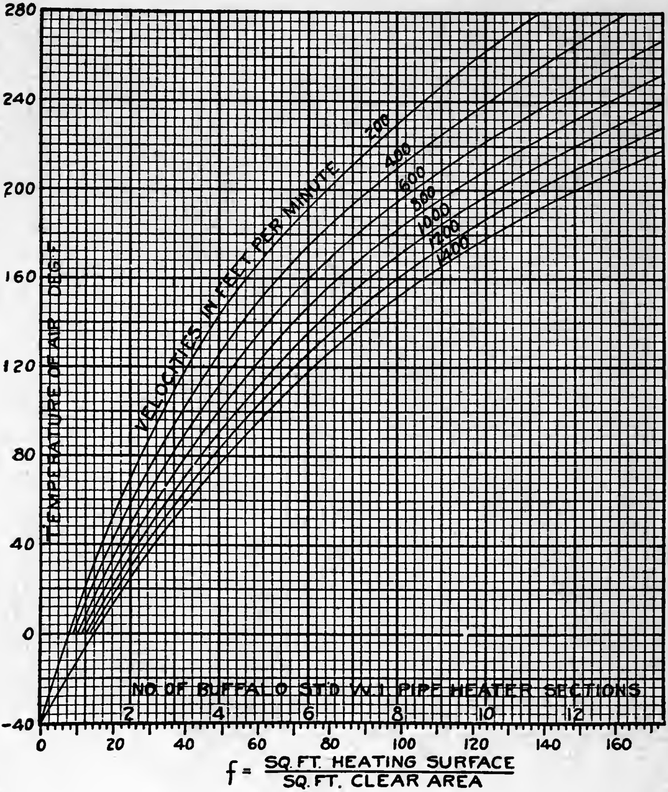


Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 40 Lbs.

Temperature, 286.7° F.

For Explanation of Curves, see pages 415 and 432

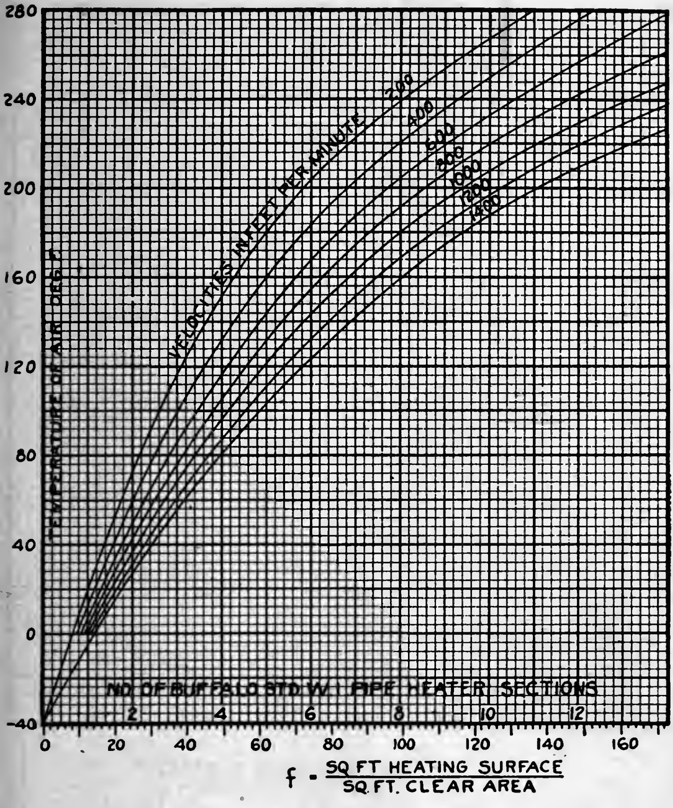


Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 60 Lbs.

Temperature, 307.3° F.

For Explanation of Curves, see pages 415 and 432

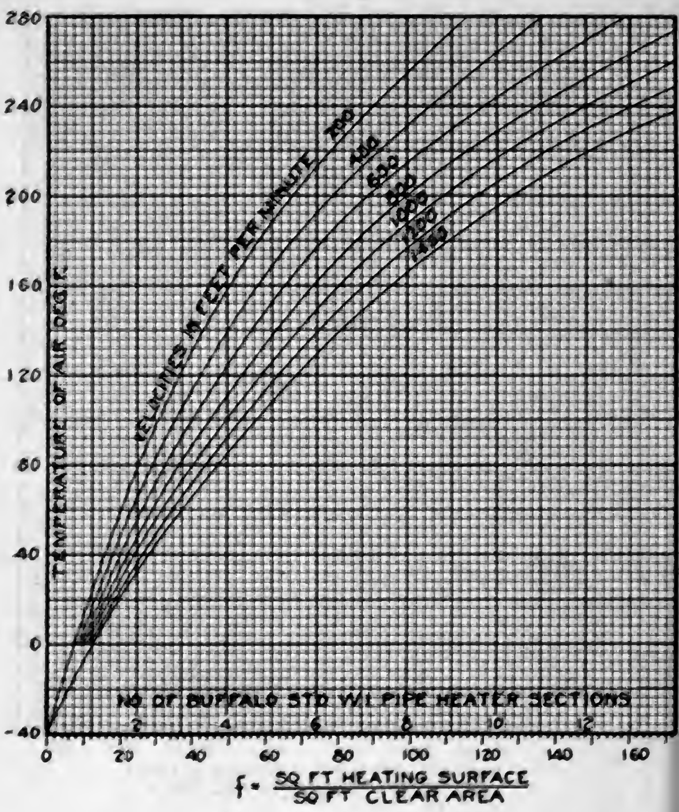


Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 80 Lbs.

Temperature, 323.7° F.

For Explanation of Curves, see pages 415 and 432



Relation Between Heater Surface and Temperature of Air at Various Velocities Measured at 70° F.

STEAM PRESSURE 100 Lbs.

Temperature, 337.6° F.

For Explanation of Curves, see pages 415 and 432

FINAL TEMPERATURES WITH VENTO CAST IRON HEATERS REGULAR SECTION—4⅝-INCH CENTERS OF LOOPS STEAM 227°, 5 LBS. GAUGE

Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	−20	31	1.66								
	0	46	1.50	42	1.82	38	2.06	35	2.28	33	2.51
	+20	62	1.37	57	1.61	54	1.85	52	2.08	50	2.28
	+40	77	1.21	73	1.43	70	1.63	68	1.82	66	1.98
	+60	93	1.07	89	1.26	87	1.47	85	1.63	83	1.75
	+70	100	.98	97	1.17	95	1.36	93	1.50	91	1.60
2	−20	70	1.47	63	1.80	57	2.09	51	2.31	47	2.55
	0	82	1.34	75	1.63	69	1.87	65	2.11	61	2.32
	+20	94	1.21	87	1.46	82	1.68	78	1.89	75	2.09
	+40	106	1.07	100	1.30	95	1.49	91	1.66	88	1.82
	+60	118	.94	112	1.13	108	1.30	105	1.46	102	1.60
	+70	124	.88	119	1.06	115	1.22	112	1.37	109	1.48
3	−20	100	1.30	91	1.61	84	1.88	78	2.13	72	2.33
	0	110	1.20	101	1.46	94	1.70	89	1.93	84	2.13
	+20	119	1.07	110	1.30	104	1.52	98	1.69	94	1.87
	+40	128	.96	120	1.16	115	1.36	110	1.52	106	1.67
	+60	137	.84	130	1.01	125	1.18	121	1.33	118	1.47
	+70	141	.77	135	.94	131	1.10	127	1.24	124	1.37
4	−20	123	1.16	114	1.46	105	1.70	99	1.94	93	2.15
	0	131	1.07	122	1.32	114	1.55	108	1.76	103	1.96
	+20	138	.96	130	1.20	123	1.41	117	1.58	112	1.75
	+40	145	.86	138	1.06	132	1.25	126	1.40	122	1.56
	+60	152	.75	146	.93	140	1.09	135	1.22	131	1.35
	+70	156	.70	150	.87	145	1.02	140	1.14	136	1.25
5	−20	142	1.05	132	1.32	124	1.56	116	1.77	110	1.98
	0	147	.96	138	1.20	131	1.42	124	1.61	118	1.79
	+20	152	.86	144	1.08	137	1.27	131	1.45	126	1.61
	+40	158	.77	151	.96	145	1.14	139	1.29	135	1.44
	+60	164	.68	158	.85	152	1.00	147	1.13	143	1.26
6	−20	155	.95	146	1.20	139	1.44	132	1.65	125	1.83
	0	160	.87	152	1.10	145	1.31	138	1.50	132	1.67
	+20	164	.78	156	.99	150	1.18	144	1.35	139	1.51
	+40	170	.71	162	.88	156	1.05	151	1.20	146	1.34
7	−20	167	.87	158	1.10	150	1.32	144	1.53	138	1.72

FINAL TEMPERATURES WITH VENTO CAST IRON HEATERS
REGULAR SECTION—5-INCH CENTERS OF LOOPS
STEAM 227°, 5 LBS. GAUGE

Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	0	43	1.65	38	1.95	35	2.24	32	2.46		
	+20	58	1.46	54	1.75	51	1.99	49	2.23	47	2.42
	+40	74	1.31	70	1.54	68	1.80	66	2.00	64	2.16
	+60	90	1.15	86	1.34	84	1.54	82	1.69	81	1.89
	+70	97	1.04	94	1.23	92	1.41	90	1.54	89	1.71
2	−20	63	1.60	55	1.92	49	2.22	44	2.46	40	2.69
	0	75	1.44	68	1.74	62	1.99	58	2.23	54	2.42
	+20	87	1.29	81	1.57	76	1.80	72	2.00	69	2.20
	+40	100	1.15	94	1.39	90	1.60	86	1.77	83	1.93
	+60	112	1.00	107	1.21	103	1.38	100	1.54	98	1.71
	+70	118	.92	114	1.13	110	1.28	107	1.42	105	1.57
3	−20	91	1.42	82	1.74	75	2.03	69	2.28	64	2.51
	0	101	1.30	93	1.59	86	1.84	81	2.08	76	2.27
	+20	110	1.15	103	1.42	97	1.65	92	1.85	88	2.06
	+40	121	1.04	114	1.26	109	1.47	104	1.64	100	1.79
	+60	131	.91	124	1.09	120	1.28	116	1.44	113	1.58
	+70	136	.85	130	1.03	126	1.20	122	1.34	119	1.46
4	−20	114	1.29	103	1.58	96	1.86	90	2.12	84	2.34
	0	121	1.16	113	1.45	106	1.70	100	1.92	95	2.13
	+20	130	1.06	122	1.31	115	1.52	110	1.73	105	1.91
	+40	138	.94	130	1.15	124	1.35	119	1.52	115	1.68
	+60	146	.83	139	1.01	134	1.19	129	1.33	125	1.46
	+70	150	.77	143	.94	138	1.09	134	1.23	131	1.37
5	−20	132	1.17	122	1.46	114	1.72	107	1.95	100	2.15
	0	138	1.06	129	1.32	122	1.56	115	1.77	109	1.96
	+20	144	.95	136	1.19	130	1.41	124	1.60	119	1.78
	+40	151	.85	144	1.07	138	1.26	132	1.42	127	1.56
	+60	158	.75	151	.93	145	1.09	140	1.23	136	1.36
	+70	162	.71	155	.87	149	1.01	144	1.14	141	1.27
6	−20	146	1.06	137	1.34	129	1.59	121	1.81	115	2.02
	0	152	.97	143	1.22	135	1.44	129	1.65	123	1.84
	+20	156	.87	148	1.10	142	1.30	136	1.49	130	1.65
	+40	162	.78	154	.97	148	1.15	143	1.32	138	1.47
	+60	167	.69	160	.85	155	1.02	150	1.15	146	1.29
7	−20	159	.98	150	1.25	141	1.47	134	1.69	128	1.90
	0	163	.90	154	1.13	147	1.35	140	1.54	135	1.73
	+20	167	.81	159	1.02	152	1.21	146	1.39	141	1.55
	+40	171	.72	164	.91	158	1.08	153	1.24	148	1.39
8	−20	168	.90	159	1.15	151	1.37	144	1.58	138	1.77
	0	172	.83	164	1.05	156	1.25	150	1.44	144	1.62
	+20	175	.75	167	.94	161	1.13	155	1.30	150	1.46
	+40	179	.67	171	.84	165	1.00	160	1.15	155	1.29

FINAL TEMPERATURES WITH VENTO CAST IRON HEATERS REGULAR SECTION—5⅜-INCH CENTERS OF LOOPS STEAM 227°, 5 LBS. GAUGE

Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	0	34	1.54	32	1.93						
	+20	51	1.40	48	1.69	46	1.96	44	2.17	42	2.32
	+40	68	1.27	65	1.51	63	1.73	61	1.90	59	2.01
	+60	85	1.13	82	1.33	80	1.51	78	1.63	77	1.79
	+70	93	1.04	90	1.21	88	1.36	87	1.54	86	1.69
2	−20	49	1.56	43	1.90	38	2.19	34	2.44		
	0	62	1.40	57	1.72	52	1.96	48	2.17	45	2.38
	+20	76	1.27	71	1.54	67	1.77	64	1.99	61	2.16
	+40	90	1.13	85	1.36	82	1.58	79	1.76	76	1.90
	+60	104	1.00	99	1.18	96	1.36	94	1.54	92	1.69
	+70	110	.91	106	1.08	103	1.25	101	1.40	99	1.53
3	−20	76	1.45	68	1.77	61	2.04	56	2.29	51	2.50
	0	87	1.31	80	1.61	74	1.86	69	2.08	65	2.25
	+20	98	1.18	91	1.43	85	1.63	81	1.84	78	2.04
	+40	109	1.04	103	1.27	98	1.46	94	1.63	91	1.79
	+60	120	.90	115	1.11	111	1.28	108	1.45	105	1.58
	+70	126	.84	121	1.03	118	1.21	115	1.36	112	1.48
4	−20	97	1.32	88	1.63	80	1.89	74	2.13	69	2.34
	0	105	1.19	97	1.46	91	1.72	86	1.95	81	2.14
	+20	115	1.07	108	1.33	101	1.53	96	1.72	92	1.90
	+40	125	.96	118	1.18	112	1.36	108	1.54	104	1.69
	+60	135	.85	128	1.02	123	1.19	119	1.34	116	1.48
	+70	140	.79	133	.95	129	1.11	125	1.25	122	1.37
5	−20	116	1.23	106	1.52	98	1.78	91	2.01	86	2.24
	0	124	1.12	115	1.39	107	1.61	101	1.83	96	2.03
	+20	131	1.00	123	1.24	117	1.46	111	1.65	106	1.82
	+40	139	.89	131	1.10	126	1.30	121	1.46	116	1.60
	+60	147	.79	140	.96	135	1.13	130	1.26	126	1.39
	+70	151	.73	145	.90	140	1.05	135	1.17	132	1.31
6	−20	131	1.14	121	1.42	112	1.66	106	1.90	100	2.11
	0	138	1.04	128	1.29	120	1.51	114	1.72	108	1.90
	+20	144	.93	136	1.17	129	1.37	123	1.55	118	1.72
	+40	150	.83	143	1.04	137	1.22	132	1.39	127	1.53
	+60	157	.73	150	.91	145	1.07	140	1.21	136	1.34
	+70	160	.68	154	.85	149	.99	145	1.13	141	1.25
7	−20	145	1.07	135	1.34	127	1.58	120	1.81	113	2.00
	0	151	.98	141	1.21	133	1.43	127	1.64	121	1.82
	+20	153	.86	146	1.09	140	1.29	134	1.47	129	1.64
	+40	159	.77	152	.96	146	1.14	140	1.29	136	1.45
	+60	165	.68	158	.84	153	1.00	148	1.14	144	1.27
	+70	168	.63	162	.79	157	.94	152	1.06	148	1.18
8	−20	155	.99	146	1.25	138	1.49	131	1.71	125	1.91
	0	160	.90	151	1.14	144	1.36	137	1.55	131	1.73
	+20	164	.81	156	1.03	149	1.22	143	1.39	138	1.56
	+40	169	.73	161	.91	155	1.08	149	1.24	144	1.37
	+60	173	.64	166	.80	160	.94	155	1.07	151	1.20

FINAL TEMPERATURES WITH VENTO CAST IRON HEATERS
NARROW SECTION—4⅝-INCH CENTERS OF LOOPS
STEAM 227°, 5 LBS. GAUGE

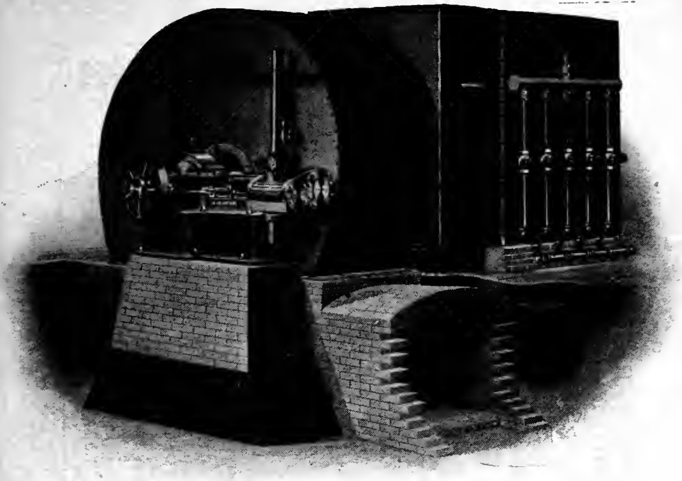
Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	0	34	1.59								
	+20	51	1.45	47	1.68	45	1.95	43	2.15	41	2.30
	+40	67	1.27	64	1.49	62	1.72	60	1.87	59	2.08
	+60	84	1.13	81	1.31	79	1.49	78	1.68	77	1.86
	+70	92	1.03	90	1.25	88	1.40	87	1.59	86	1.75
2	−20	48	1.59	42	1.94	37	2.22	33	2.48		
	0	62	1.45	56	1.75	51	1.99	47	2.20	44	2.40
	+20	76	1.31	70	1.56	66	1.80	63	2.02	60	2.19
	+40	90	1.17	85	1.40	82	1.64	79	1.83	76	1.97
	+60	104	1.03	99	1.22	96	1.41	94	1.59	92	1.74
	+70	111	.96	106	1.13	103	1.29	101	1.45	99	1.59
3	−20	74	1.47	66	1.79	59	2.06	54	2.31	49	2.51
	0	85	1.33	78	1.62	71	1.85	66	2.06	62	2.26
	+20	96	1.19	89	1.44	84	1.66	80	1.87	76	2.04
	+40	108	1.06	101	1.27	97	1.48	93	1.65	90	1.82
	+60	120	.94	114	1.13	110	1.30	106	1.44	103	1.57
	+70	126	.87	120	1.04	116	1.20	113	1.34	110	1.46
4	−20	95	1.35	86	1.66	79	1.93	73	2.18	67	2.38
	0	104	1.22	96	1.50	90	1.75	84	1.97	79	2.16
	+20	113	1.09	106	1.34	100	1.56	95	1.76	91	1.94
	+40	123	.97	117	1.20	112	1.40	107	1.57	103	1.72
	+60	133	.86	127	1.05	122	1.21	118	1.36	115	1.50
	+70	138	.80	132	.97	128	1.13	124	1.27	121	1.39
5	−20	113	1.25	103	1.54	95	1.79	88	2.02	82	2.23
	0	120	1.13	112	1.40	104	1.62	98	1.84	92	2.01
	+20	127	1.00	120	1.25	114	1.47	109	1.67	104	1.84
	+40	137	.90	130	1.12	124	1.31	119	1.48	115	1.64
	+60	145	.80	139	.98	134	1.16	129	1.29	125	1.42
	+70	150	.75	144	.91	139	1.08	134	1.20	131	1.33
6	−20	127	1.15	117	1.43	109	1.68	103	1.92	97	2.13
	0	134	1.05	125	1.30	118	1.53	112	1.75	106	1.93
	+20	140	.94	132	1.17	125	1.37	119	1.55	114	1.71
	+40	148	.84	140	1.04	134	1.22	128	1.37	124	1.53
	+60	155	.74	148	.92	142	1.07	137	1.20	133	1.33
	+70	159	.69	152	.85	147	1.00	142	1.12	138	1.24
7	−20	140	1.07	130	1.34	121	1.58	114	1.80	108	2.00
	0	146	.98	136	1.21	129	1.44	122	1.63	116	1.81
	+20	151	.88	143	1.10	136	1.30	130	1.47	125	1.64
8	−20	150	1.00	141	1.26	133	1.49	125	1.70	119	1.90
	0	155	.91	146	1.14	138	1.35	132	1.55	126	1.72

FINAL TEMPERATURE WITH VENTO CAST IRON HEATERS
NARROW SECTION—5-INCH CENTERS OF LOOPS
STEAM 227°, 5 LBS. GAUGE

Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	+20	47	1.49	45	1.84	43	2.12	41	2.32	39	2.45
	+40	64	1.33	62	1.62	60	1.84	58	1.99	57	2.19
	+60	82	1.22	80	1.47	78	1.66	76	1.77	75	1.94
	+70	90	1.11	88	1.33	86	1.47	85	1.66	84	1.81
2	−20	41	1.69	36	2.06	31	2.35				
	0	56	1.55	51	1.88	46	2.12	43	2.38	40	2.58
	+20	70	1.38	65	1.66	62	1.93	59	2.16	56	2.32
	+40	85	1.24	80	1.47	77	1.70	74	1.88	72	2.06
	+60	99	1.08	95	1.29	92	1.47	90	1.66	88	1.81
	+70	106	1.00	102	1.18	100	1.38	98	1.55	96	1.68
3	−20	65	1.57	58	1.92	52	2.21	47	2.47	43	2.71
	0	77	1.42	70	1.72	65	2.00	61	2.25	57	2.45
	+20	90	1.29	84	1.57	79	1.81	75	2.03	71	2.19
	+40	102	1.14	97	1.40	92	1.60	88	1.77	85	1.94
	+60	114	.99	109	1.20	105	1.38	102	1.55	100	1.72
	+70	120	.92	115	1.10	112	1.29	109	1.44	107	1.59
4	−20	86	1.46	77	1.79	70	2.07	64	2.32	59	2.55
	0	96	1.33	88	1.62	82	1.89	77	2.13	72	2.32
	+20	106	1.19	99	1.46	93	1.68	88	1.88	84	2.06
	+40	117	1.06	110	1.29	105	1.50	101	1.69	98	1.87
	+60	127	.93	121	1.12	117	1.31	113	1.47	110	1.61
	+70	132	.86	127	1.05	123	1.22	119	1.36	116	1.48
5	−20	102	1.35	93	1.67	86	1.95	79	2.19	74	2.43
	0	111	1.23	103	1.52	96	1.77	90	1.99	85	2.20
	+20	120	1.10	113	1.37	106	1.58	101	1.79	96	1.96
	+40	129	.98	122	1.21	117	1.42	112	1.59	108	1.76
	+60	138	.86	132	1.06	127	1.23	123	1.39	119	1.52
	+70	142	.80	136	.97	132	1.14	128	1.28	125	1.42
6	−20	116	1.25	107	1.56	99	1.83	92	2.06	87	2.30
	0	124	1.14	115	1.41	108	1.66	102	1.88	97	2.09
	+20	132	1.03	124	1.28	118	1.51	112	1.70	107	1.87
	+40	140	.92	133	1.14	127	1.34	122	1.51	118	1.68
	+60	148	.81	142	1.01	137	1.18	132	1.33	128	1.46
	+70	152	.76	146	.93	141	1.09	136	1.22	133	1.36
7	−20	130	1.18	120	1.47	112	1.74	105	1.97	99	2.19
	0	136	1.07	127	1.34	120	1.58	114	1.80	108	1.99
	+20	142	.96	134	1.20	128	1.42	122	1.61	117	1.79
	+40	150	.87	142	1.07	136	1.26	131	1.43	126	1.59
8	−20	140	1.11	130	1.38	122	1.64	115	1.87	109	2.08
	0	146	1.01	137	1.26	129	1.49	123	1.70	118	1.90
	+20	152	.91	144	1.14	137	1.35	131	1.53	125	1.69

FINAL TEMPERATURES WITH VENTO CAST IRON HEATERS
NARROW SECTION—5⅝-INCH CENTERS OF LOOPS
STEAM 227°, 5 LBS. GAUGE

Number of Stacks Deep	Temperature of Entering Air	Velocity Through Heater in Ft. per Min. Measured at 70°									
		600		800		1000		1200		1400	
		Final Temp. Air Leaving Heater	Cond. Lbs. per Sq. Ft. per Hour	F. T.	C.	F. T.	C.	F. T.	C.	F. T.	C.
1	+20	42	1.43	40	1.73	38	1.95	37	2.21	36	2.43
	+40	60	1.30	58	1.56	56	1.73	55	1.95	54	2.12
	+60	78	1.17	76	1.39	74	1.52	73	1.69	72	1.82
	+70	86	1.04	84	1.21	83	1.41	82	1.56	81	1.67
2	0	46	1.50	42	1.82	38	2.06	35	2.27	32	2.43
	+20	61	1.33	57	1.60	54	1.84	52	2.08	50	2.28
	+40	77	1.20	73	1.43	71	1.68	69	1.88	67	2.05
	+60	93	1.07	89	1.26	87	1.46	85	1.63	83	1.75
	+70	101	1.01	97	1.17	95	1.35	93	1.50	91	1.59
3	−20	52	1.56	46	1.90	40	2.17	36	2.43	33	2.68
	0	65	1.41	59	1.70	54	1.95	50	2.17	47	2.38
	+20	79	1.28	73	1.53	69	1.77	66	2.00	63	2.17
	+40	92	1.13	87	1.36	83	1.55	80	1.73	77	1.87
	+60	105	.98	101	1.19	97	1.34	94	1.47	92	1.62
	+70	112	.91	108	1.10	105	1.26	102	1.39	100	1.52
4	−20	71	1.48	63	1.80	57	2.08	52	2.34	47	2.54
	0	82	1.33	75	1.63	69	1.87	65	2.11	61	2.32
	+20	94	1.20	88	1.47	83	1.71	78	1.89	74	2.05
	+40	106	1.07	100	1.30	95	1.49	91	1.66	88	1.82
	+60	118	.94	112	1.13	108	1.30	104	1.43	101	1.56
	+70	124	.88	118	1.04	114	1.19	111	1.33	108	1.44
5	−20	88	1.41	79	1.72	72	1.99	66	2.24	61	2.46
	0	98	1.27	90	1.56	83	1.80	78	2.03	73	2.22
	+20	107	1.13	100	1.39	94	1.60	90	1.82	86	2.00
	+40	117	1.00	111	1.23	106	1.43	102	1.61	98	1.76
	+60	128	.88	123	1.09	118	1.26	114	1.41	111	1.55
	+70	133	.82	128	1.00	124	1.17	120	1.30	117	1.43
6	−20	102	1.32	93	1.63	85	1.90	79	2.74	73	2.35
	0	110	1.19	102	1.47	95	1.72	89	1.93	84	2,12
	+20	119	1.07	111	1.31	105	1.54	100	1.73	96	1.92
	+40	128	.95	121	1.17	116	1.37	111	1.54	107	1.70
	+60	138	.85	131	1.03	126	1.19	122	1.34	118	1.47
	+70	143	.79	137	.97	132	1.12	128	1.25	124	1.37
7	−20	115	1.26	106	1.56	98	1.83	91	2.06	86	2.30
	0	123	1.14	114	1.41	107	1.65	101	1.88	96	2.08
	+20	131	1.03	123	1.28	117	1.50	111	1.69	106	1.86
	+40	139	.92	131	1.13	126	1.33	121	1.51	116	1.65
	+60	147	.81	140	.99	135	1.16	130	1.30	126	1.43
8	−20	126	1.19	117	1.48	109	1.75	102	1.98	96	2.20
	0	133	1.08	124	1.34	117	1.59	111	1.80	105	1.99
	+20	140	.98	132	1.21	126	1.44	120	1.62	115	1.80
	+40	147	.87	140	1.08	134	1.27	129	1.45	124	1.59



Left-Hand Bottom Horizontal Discharge Fan Drawing Through Heater

Full Housing Top Horizontal Discharge Fan Blowing Air Through and Underneath Heater

FRICTION OF AIR THROUGH BUFFALO HEATERS
REGULAR OPEN AREA AND RETURN BEND PATTERN—AIR AT 70° F.

Loss of Air Pressure in Inches of Water Per Square Inch

Velocity through Clear Area	Number of Sections							
	1	2	3	4	5	6	7	8
300	0.009	0.017	0.026	0.035	0.043	0.052	0.060	0.069
400	0.015	0.031	0.046	0.062	0.077	0.092	0.108	0.123
500	0.024	0.049	0.073	0.095	0.104	0.144	0.168	0.192
600	0.035	0.069	0.104	0.138	0.173	0.207	0.242	0.276
700	0.047	0.094	0.141	0.188	0.235	0.282	0.329	0.376
800	0.061	0.123	0.184	0.245	0.306	0.368	0.429	0.490
900	0.078	0.155	0.233	0.311	0.388	0.466	0.544	0.621
1000	0.096	0.191	0.287	0.382	0.479	0.574	0.670	0.765
1100	0.116	0.232	0.347	0.463	0.579	0.695	0.810	0.926
1200	0.138	0.276	0.414	0.551	0.689	0.827	0.965	1.103
1300	0.162	0.324	0.486	0.648	0.810	0.972	1.133	1.296
1400	0.187	0.375	0.562	0.750	0.936	1.124	1.311	1.500
1500	0.215	0.431	0.646	0.861	1.077	1.293	1.508	1.722
1600	0.245	0.490	0.735	0.980	1.226	1.471	1.716	1.961
1700	0.277	0.555	0.831	1.110	1.387	1.664	1.940	2.218
1800	0.310	0.620	0.930	1.240	1.550	1.860	2.167	2.480

FRICTION OF AIR THROUGH VENTO HEATERS

Loss in Pressure in Inches of Water

Velocity Ft. per Min.	Regular Section 5-Inch Centers					
	1 Stack	2 Stack	3 Stack	4 Stack	5 Stack	6 Stack
600	0.022	0.040	0.058	0.076	0.094	0.112
700	0.030	0.055	0.080	0.105	0.130	0.155
800	0.040	0.072	0.104	0.136	0.168	0.200
900	0.051	0.091	0.131	0.172	0.213	0.254
1000	0.063	0.113	0.163	0.213	0.263	0.313
1100	0.076	0.136	0.196	0.257	0.318	0.379
1200	0.090	0.162	0.234	0.306	0.378	0.450
1300	0.105	0.190	0.275	0.360	0.445	0.530
1400	0.122	0.220	0.318	0.416	0.514	0.612
1500	0.140	0.252	0.364	0.477	0.590	0.703
1600	0.160	0.288	0.416	0.544	0.672	0.800

Velocity Ft. per Min.	Narrow Section 5-Inch Centers					
	2 Stack	3 Stack	4 Stack	5 Stack	6 Stack	7 Stack
600	0.028	0.043	0.058	0.073	0.088	0.103
700	0.037	0.057	0.077	0.098	0.119	0.140
800	0.048	0.075	0.102	0.128	0.155	0.181
900	0.061	0.095	0.128	0.162	0.196	0.230
1000	0.075	0.117	0.158	0.199	0.241	0.283
1100	0.090	0.140	0.190	0.240	0.290	0.340
1200	0.107	0.167	0.227	0.287	0.347	0.407
1300	0.126	0.196	0.266	0.336	0.406	0.476
1400	0.147	0.229	0.311	0.392	0.473	0.554
1500	0.170	0.263	0.356	0.449	0.542	0.635
1600	0.194	0.300	0.406	0.512	0.617	0.722

From Catalog of American Radiator Company.

Friction Through Heaters

On pages 446 and 447 will be found tables giving the friction loss or drop in pressure through both the Buffalo Standard Heaters and the Vento Cast Iron Heaters, with different velocities and depths of heaters. The values given for Buffalo heaters are based on tests made by the Buffalo Forge Company and will be found accurate for pipe coils. The table of loss through Vento heaters is based on tests made by the American Radiator Company.

Sizes and Dimensions of Buffalo Standard Heaters

The table on page 449 of the Sizes and Dimensions of Buffalo Standard Heaters gives the information required for the selection of a heater for any specific case. The third column gives the length of the section (or of the cast-iron base) as also the number of rows of pipe in the section. The fifth row gives the various heights that are made on each base. Thus a heater 4′×6′10″ is 4 feet across the face by 6 feet 10 inches high.

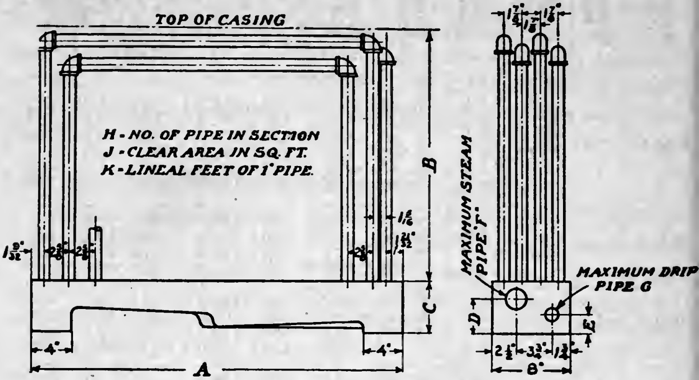
Three columns are given showing measurements of the surface in the section. One gives the actual measured lineal feet of one inch pipe in each section. The next gives the actual effective square feet of heating surface in the section, counting in the exposed portions of the base as well as the surface of the pipe fittings. The third column gives the equivalent of this surface expressed in lineal feet of one inch pipe. Thus in the 4′×6′10″ section there are 428 feet of one inch pipe, but the total exposed heating surface is equivalent to 455 lineal feet of one inch pipe.

The column of clear areas gives the actual clear area, expressed in square feet, for the passage of air through the heater. Having the quantity of air and the velocity through the heater given, the values in this column decide the size of heater to be used. The number of sections in depth of the heater will depend on the desired temperature rise to be obtained.

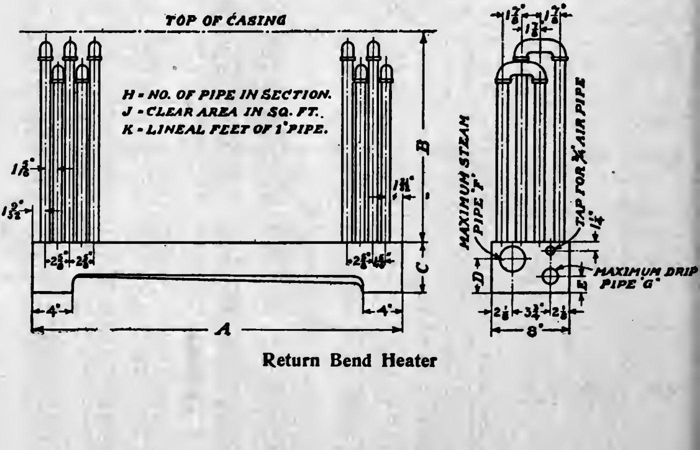
SIZES AND DIMENSIONS OF BUFFALO STANDARD HEATERS

Manner of Piping	Number of Pipes	Length of Section	Section Number	Extreme Height Section	Width of Section	Lin. Feet of 1-inch Pipe per Section	Total Effective Sq. Ft. Heating Surface	Equivalent in Lin. Feet of 1-Inch Pipe	Clear Area for Air Passage Sq. Ft.	Weight
R.O.A.	56	3′ 4 row	1 A	3′ 4″	8½″	140	54.7	159	4.4	473
			2 A	3′ 10″	8½″	168	64.2	186	5.2	515
			3 A	4′ 4″	8½″	196	74.0	215	6.0	565
			4 A	4′ 10″	8½″	224	83.7	243	6.8	616
			5 A	5′ 4″	8½″	252	93.3	271	7.6	656
			6 A	5′ 10″	8½″	280	102.5	298	8.4	708
R.O.A.	72	4′ 4 row	1 B	5′ 4″	8½″	320	119.0	346	9.7	819
			2 B	5′ 10″	8½″	356	131.5	382	10.7	877
			3 B	6′ 4″	8½″	392	143.9	418	11.2	938
			4 B	6′ 10″	8½″	428	156.5	455	12.6	1003
R.O.A.	80	4′ 6″ 4 row	1 C	5′ 10″	8½″	396	148.2	431	12.1	997
			2 C	6′ 4″	8½″	436	162.0	480	13.1	1055
			3 C	6′ 10″	8½″	476	174.8	507	14.2	1127
			4 C	7′ 4″	8½″	516	188.6	548	15.3	1174
R.O.A.	88	5′ 4 row	1 D	6′ 4″	8½″	476	174.3	507	14.1	1182
			2 D	6′ 10″	8½″	520	189.3	550	15.4	1262
			3 D	7′ 4″	8½″	564	204.8	595	16.6	1325
			4 D	7′ 10″	8½″	608	219.8	638	17.7	1407
R.O.A.	104	6′ 4 row	1 E	7′ 4″	8½″	674	245.0	712	19.8	1505
			2 E	7′ 10″	8½″	726	262.9	763	21.3	1600
			3 E	8′ 4″	8½″	778	280.8	816	22.7	1695
			4 E	8′ 10″	8½″	830	298.7	868	24.2	1770
R.O.A.	64	7′ 2 row	1 F	8′ 4″	6″	477	173.1	503	28.1	1198
			2 F	8′ 10″	6″	509	184.3	535	30.0	1244
			3 F	9′ 4″	6″	541	195.3	567	31.7	1303
			4 F	9′ 10″	6″	573	205.3	596	33.3	1350
R.B.	128	7′ 4 row	1 G	7′ 4″	8½″	796	291.0	845	23.6	1845
			2 G	7′ 10″	8½″	860	313.2	910	25.4	1950
			3 G	8′ 4″	8½″	924	335.2	974	27.2	2055
			4 G	8′ 10″	8½″	988	357.2	1037	29.0	2160
			5 G	9′ 4″	8½″	1052	379.2	1101	30.7	2280
			6 G	9′ 10″	8½″	1116	401.2	1163	32.5	2380
R.B.	154	8′ 6″ 4 row	1 H	8′ 4″	10″	1119	410.2	1190	33.2	2675
			2 H	8′ 10″	10″	1196	436.8	1265	35.3	2800
			3 H	9′ 4″	10″	1273	463.5	1345	37.6	3075
			4 H	9′ 10″	10″	1350	490.0	1421	39.8	3200
			5 H	10′ 4″	10″	1427	516.6	1499	41.8	3325
			6 H	10′ 10″	10″	1504	543.2	1578	44.0	3455
R.B.	170	9′ 6″ 4 row	1 I	8′ 4″	10″	1231	452.3	1313	36.7	3205
			2 I	8′ 10″	10″	1316	481.6	1396	39.0	3350
			3 I	9′ 4″	10″	1401	510.9	1481	41.4	3485
			4 I	9′ 10″	10″	1486	540.2	1570	43.8	3625
			5 I	10′ 4″	10″	1571	569.5	1651	46.0	3770
			6 I	10′ 10″	10″	1656	598.7	1739	48.4	3910
			7 I	11′ 4″	10″	1741	628.0	1821	50.8	4060
			8 I	11′ 10″	10″	1826	657.3	1910	53.2	4200

BUFFALO STANDARD PIPE COIL HEATERS



Regular O. A. P. Heater

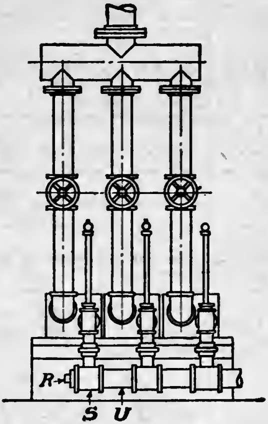


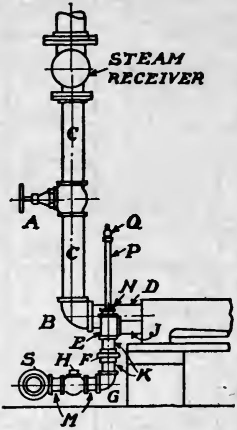
Return Bend Heater

DIMENSIONS OF REGULAR O. A. P. AND RETURN BEND HEATERS

Size of Section		A	B	C	D	E	F	G	H	J	K
Length	Height										
3 ft.	3′ 4″	38⅜″	34″	5″	3⅛″	2″	2″	1″	56	5.1	158
	3′10″	38⅜″	38″	5″	3⅛″	2″	2″	1″	56	5.4	178
	4′ 4″	38⅜″	44″	5″	3⅛″	2″	2″	1″	56	6.1	193
	4′10″	38⅜″	50″	5″	3⅛″	2″	2″	1″	56	6.9	221
	5′ 4″	38⅜″	56″	5″	3⅛″	2″	2″	1″	56	7.7	249
	5′10″	38⅜″	62″	5″	3⅛″	2″	2″	1″	56	8.5	277
4 ft.	5′ 4″	48⅞″	56″	5⅝″	3½″	2⅛″	2½″	1¼″	72	9.8	320
	5′10″	48⅞″	62″	5⅝″	3½″	2⅛″	2½″	1¼″	72	10.8	356
	6′ 4″	48⅞″	68″	5⅝″	3½″	2⅛″	2½″	1¼″	72	11.8	392
	6′10″	48⅞″	74″	5⅝″	3½″	2⅛″	2½″	1¼″	72	12.9	428
4 ft. 6 in.	5′10″	54⅛″	62″	5⅝″	3½″	2⅛″	2½″	1¼″	80	12.0	396
	6′ 4″	54⅛″	68″	5⅝″	3½″	2⅛″	2½″	1¼″	80	13.0	436
	6′10″	54⅛″	74″	5⅝″	3½″	2⅛″	2½″	1¼″	80	14.0	477
	7′ 4″	54⅛″	80″	5⅝″	3½″	2⅛″	2½″	1¼″	80	15.0	516
5 ft.	6′ 4″	59⅜″	68″	6⅜″	3 15/16″	2 5/16″	3″	1½″	88	14.3	479
	6′10″	59⅜″	74″	6⅜″	3 15/16″	2 5/16″	3″	1½″	88	15.6	523
	7′ 4″	59⅜″	80″	6⅜″	3 15/16″	2 5/16″	3″	1½″	88	16.8	567
	7′10″	59⅜″	86″	6⅜″	3 15/16″	2 5/16″	3″	1½″	88	17.8	611
6 ft.	7′ 4″	69⅞″	80″	6⅜″	3 15/16″	2 5/16″	3″	1½″	104	19.7	670
	7′10″	69⅞″	86″	6⅜″	3 15/16″	2 5/16″	3″	1½″	104	21.2	722
	8′ 4″	69⅞″	92″	6⅜″	3 15/16″	2 5/16″	3″	1½″	104	22.7	774
	8′10″	69⅞″	98″	6⅜″	3 15/16″	2 5/16″	3″	1½″	104	24.2	826
7 ft.	8′ 4″	85⅝″	92″	6⅜″	3 15/16″	2 5/16″	3″	1½″	128	27.0	960
	8′10″	85⅝″	98″	6⅜″	3 15/16″	2 5/16″	3″	1½″	128	29.0	1024
	9′ 4″	85⅝″	104″	6⅜″	3 15/16″	2 5/16″	3″	1½″	128	30.8	1088
	9′10″	85⅝″	110″	6⅜″	3 15/16″	2 5/16″	3″	1½″	128	32.5	1152

STEAM, DRIP AND AIR CONNECTIONS FOR REGULAR O. A. P. HEATERS





LIST OF FITTINGS FOR ONE SECTION

Steam Connections

1 Globe Valve "A"
1 Elbow "B"
2 Nipples "C"
1 Nipple "D"

Drip and Air Connections

1 Tee "E"
1 Box Union "F"
1 Elbow "G"
1 Check Valve "H"
1 Nipple "J"
2 Nipples "K"
2 Short Nipples "M"
1 Bushing "N"
1—¾″ Pipe "P" 12″ long
1—¼″ Pet Cock "Q"
Female Thread

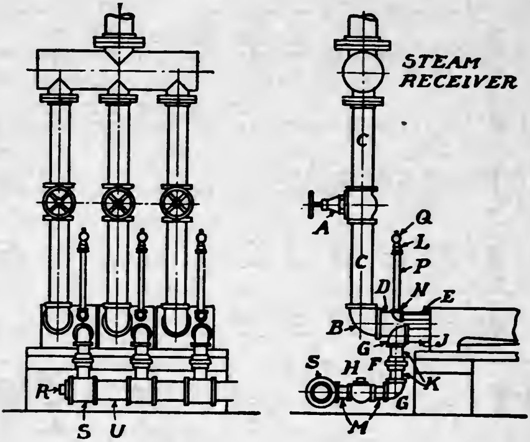
Main Drip

1 Pipe Plug "R"
Tees "S." Same number as Number of Sections
Nipples "U." One less than Number of Sections

STEAM, DRIP AND AIR CONNECTIONS FOR REGULAR O. A. P. HEATERS

Size of Heater	Size of Steam Supply				Length of Nipples		Size of Drip	Size of Main Drip					Length of Nipples		
	0 Lbs.	5 Lbs.	20 Lbs.	60 Lbs.	C	D		2 Sect.	3 Sect.	4 Sect.	5 Sect.	6 Sect.	J	K	U
3'0"x3' 4" 3'0"x3'10"	1½ 1½	1¼ 1¼	1 1	1 1	12 12	6 6	1 1	1¼ 1¼	1½ 1½	1½ 1½	2 2	2 2	4 4	3 3	6½ 6½
3'0"x4' 4" 3'0"x4'10"	2 2	1½ 1½	1¼ 1¼	1 1	18 18	6 6	1 1	1¼ 1¼	1½ 1½	1½ 1½	2 2	2 2	4 4	3 3	6½ 6½
3'0"x5' 4" 3'0"x5'10"	2 2	2 2	1¼ 1½	1 1	18 18	6 6	1 1	1¼ 1¼	1½ 1½	1½ 1½	2 2	2 2	4 4	3 3	6½ 6½
4'0"x5' 4" 4'0"x5'10"	2½ 2½	2 2	1½ 1½	1 1¼	18 18	6 6	1 1	1¼ 1¼	1½ 1½	2 2	2 2	2½ 2½	4 4	3 3	6½ 6½
4'0"x6' 4" 4'0"x6'10"	2½ 2½	2 2½	1½ 2	1¼ 1¼	18 18	6 7½	1 1¼	1¼ 1½	1½ 2	2 2	2 2½	2½ 2½	4 4	3 2½	6½ 6½
4'6"x5'10" 4'6"x6' 4"	2½ 2½	2 2½	1½ 2	1¼ 1¼	18 18	6 7½	1 1¼	1¼ 1½	1½ 2	2 2	2 2½	2½ 2½	4 4	3 2½	6½ 6⅛
4'6"x6'10" 4'6"x7' 4"	2½ 2½	2½ 2½	2 2	1¼ 1¼	18 18	7½ 7½	1¼ 1¼	1½ 1½	2 2	2 2	2½ 2½	2½ 2½	4 4	2½ 2½	6⅛ 6⅛
5'0"x6' 4" 5'0"x6'10"	2½ 3	2½ 2½	2 2	1¼ 1¼	18 18	7½ 7½	1¼ 1¼	1½ 1½	2 2	2 2	2½ 2½	2½ 2½	4 4	2½ 2½	6⅛ 6⅛
5'0"x7' 4" 5'0"x7'10"	3 3	2½ 2½	2 2	1½ 1½	18 24	7½ 7½	1¼ 1¼	1½ 1½	2 2	2 2	2½ 2½	2½ 2½	4 4	2½ 2½	6⅛ 6⅛
6'0"x7' 4" 6'0"x7'10"	3 3	3 3	2 2½	1½ 1½	18 24	8 8	1½ 1½	2 2	2½ 2½	2½ 2½	3 3	3 3	4½ 4½	2½ 2½	6 6
6'0"x8' 4" 7'0"x8'10"	3 3	3 3	2½ 2½	1½ 2	24 24	8 8	1½ 1½	2 2	2½ 2½	2½ 2½	3 3	3 3	4½ 4½	2½ 2½	6 6

STEAM, DRIP AND AIR CONNECTIONS FOR RETURN BEND HEATERS



LIST OF FITTINGS FOR ONE SECTION

Steam Connections

1 Globe Valve "A"
1 Elbow "B"
2 Nipples "C"
1 Nipple "D"

Drip Connections

2 Elbows "G"
1 Box Union "F"
1 Check Valve "H"
1 Nipple "J"
2 Nipples "K"
2 Short Nipples "M"

Air Connections

1—¾″ Short Nipple "E"
1—¾″ Elbow "N"
1—¾″ Pipe "P" 18″ long
1—¾″ x ¼″ Reducer "L"
1—¼″ Pet Cock "Q"
Male Thread

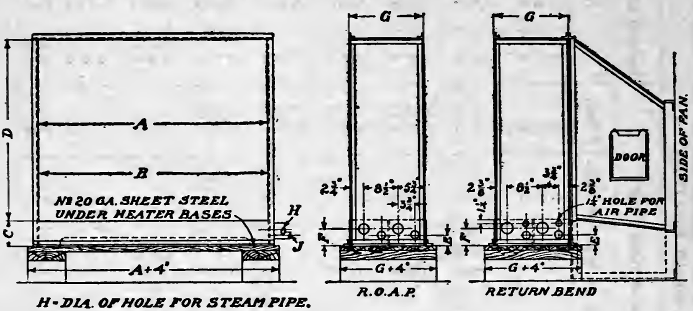
Main Drip

1 Pipe Plug "R."
Tees "S." Same Number as Number of Sections
Nipples "U." One less than Number of Sections

STEAM, DRIP AND AIR CONNECTIONS FOR RETURN BEND HEATERS

Size of Heater	Size of Steam Supply				Length of Nipples		Size of Drip	Size of Main Drip					Length of Nipples		
	0 Lbs.	5 Lbs.	20 Lbs.	60 Lbs.	C	D		2 Sect.	3 Sect.	4 Sect.	5 Sect.	6 Sect.	J	K	U
3′0″x3′ 4″	1½	1¼	1	1	12	6	1	1¼	1½	1½	2	2	4	3	6½
3′0″x3′10″	1½	1¼	1	1	12	6	1	1¼	1½	1½	2	2	4	3	6½
3′0″x4′ 4″	2	1½	1¼	1	18	6	1	1¼	1½	1½	2	2	4	3	6½
3′0″x4′10″	2	1½	1¼	1	18	6	1	1¼	1½	1½	2	2	4	3	6½
3′0″x5′ 4″	2	2	1¼	1	18	6	1	1¼	1½	1½	2	2	4	3	6½
3′0″x5′10″	2	2	1½	1	18	6	1	1¼	1½	1½	2	2	4	3	6½
4′0″x5′ 4″	2½	2	1½	1	18	6	1	1¼	1½	2	2	2½	4	3	6½
4′0″x5′10″	2½	2	1½	1¼	18	6	1	1¼	1½	2	2	2½	4	3	6½
4′0″x6′4″	2½	2	1½	1¼	18	6	1	1¼	1½	2	2	2½	4	3	6½
4′0″x6′10″	2½	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
4′6″x5′10″	2½	2	1½	1¼	18	6	1	1¼	1½	2	2	2½	4	3	6½
4′6″x6′ 4″	2½	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
4′6″x6′10″	2½	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
4′6″x7′ 4″	2½	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
5′0″x6′ 4″	2½	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
5′0″x6′10″	3	2½	2	1¼	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
5′0″x7′ 4″	3	2½	2	1½	18	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
5′0″x7′10″	3	2½	2	1½	24	7½	1¼	1½	2	2	2½	2½	4	2½	6⅛
6′0″x7′ 4″	3	3	2	1½	18	8	1½	2	2½	2½	3	3	4½	2½	6
6′0″x7′10″	3	3	2½	1½	24	8	1½	2	2½	2½	3	3	4½	2½	6
6′0″x8′ 4″	3	3	2½	1½	24	8	1½	2	2½	2½	3	3	4½	2½	6
6′0″x8′10″	3	3	2½	2	24	8	1½	2	2½	2½	3	3	4½	2½	6
7′0″x8′ 4″	3	3	2½	2	24	8	1½	2	2½	2½	3	3	4½	2½	6
7′0″x8′10″	3	3	2½	2	24	8	1½	2	2½	2½	3	3	4½	2½	6
7′0″x9′ 4″	3	3	2½	2	24	8	1½	2	2½	2½	3	3	4½	2½	6
7′0″x9′10″	3	3	2½	2	24	8	1½	2	2½	2½	3	3	4½	2½	6

DIMENSIONS OF HEATER CASE FOR BUFFALO STANDARD HEATERS



H-DIA. OF HOLE FOR STEAM PIPE.
J-DIA. OF HOLE FOR DRIP PIPE.

Size of Section		A	B	C	D	E	F	G	H				J
Length	Height								0 lbs.	5 lbs.	20 lbs.	60 lbs.	
3 ft.	3′ 4″	38 3/4	38 3/8	5	34	2	3 1/8	8 1/2″ x No. OF SECTIONS	2 1/8	1 7/8	1 1/2	1 1/2	1 1/2
	3′10″	38 3/4	38 3/8	5	38	2	3 1/8		2 1/8	1 7/8	1 1/2	1 1/2	1 1/2
	4′ 4″	38 3/4	38 3/8	5	44	2	3 1/8		2 5/8	2 1/8	1 7/8	1 1/2	1 1/2
	4′10″	38 3/4	38 3/8	5	50	2	3 1/8		2 5/8	2 1/8	1 7/8	1 1/2	1 1/2
	5′ 4″	38 3/4	38 3/8	5	56	2	3 1/8		2 5/8	2 5/8	1 7/8	1 1/2	1 1/2
	5′10″	38 3/4	38 3/8	5	62	2	3 1/8		2 5/8	2 5/8	2 1/8	1 1/2	1 1/2
4 ft.	5′ 4″	49 1/4	48 7/8	5 5/8	56	2 1/8	3 1/2		3 1/8	2 5/8	2 1/8	1 1/2	1 1/2
	5′10″	49 1/4	48 7/8	5 5/8	62	2 1/8	3 1/2		3 1/8	2 5/8	2 1/8	1 7/8	1 1/2
	6′ 4″	49 1/4	48 7/8	5 5/8	68	2 1/8	3 1/2		3 1/8	2 5/8	2 1/8	1 7/8	1 1/2
	6′10″	49 1/4	48 7/8	5 5/8	74	2 1/8	3 1/2		3 1/8	3 1/8	2 5/8	1 7/8	1 7/8
4 ft. 6 in.	5′10″	54 1/2	54 1/8	5 5/8	62	2 1/8	3 1/2		3 1/8	2 5/8	2 1/8	1 7/8	1 1/2
	6′ 4″	54 1/2	54 1/8	5 5/8	68	2 1/8	3 1/2		3 1/8	3 1/8	2 5/8	1 7/8	1 7/8
	6′10″	54 1/2	54 1/8	5 5/8	74	2 1/8	3 1/2		3 1/8	3 1/8	2 5/8	1 7/8	1 7/8
	7′ 4″	54 1/2	54 1/8	5 5/8	80	2 1/8	3 1/2		3 1/8	3 1/8	2 5/8	1 7/8	1 7/8
5 ft.	6′ 4″	59 3/4	59 3/8	6 3/8	68	2 5/16	3 15/16		3 1/8	3 1/8	2 5/8	1 7/8	1 7/8
	6′10″	59 3/4	59 3/8	6 3/8	74	2 5/16	3 15/16		3 3/4	3 1/8	2 5/8	1 7/8	1 7/8
	7′ 4″	59 3/4	59 3/8	6 3/8	80	2 5/16	3 15/16		3 3/4	3 1/8	2 5/8	2 1/8	1 7/8
	7′10″	59 3/4	59 3/8	6 3/8	86	2 5/16	3 15/16		3 3/4	3 1/8	2 5/8	2 1/8	1 7/8
6 ft.	7′ 4″	70 1/4	69 7/8	6 3/8	80	2 5/16	3 15/16		3 3/4	3 3/4	2 5/8	2 1/8	2 1/8
	7′10″	70 1/4	69 7/8	6 3/8	86	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 1/8	2 1/8
	8′ 4″	70 1/4	69 7/8	6 3/8	92	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 1/8	2 1/8
	8′10″	70 1/4	69 7/8	6 3/8	98	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 5/8	2 1/8
7 ft.	8′ 4″	86	85 5/8	6 3/8	92	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 5/8	2 1/8
	8′10″	86	85 5/8	6 3/8	98	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 5/8	2 1/8
	9′ 4″	86	85 5/8	6 3/8	104	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 5/8	2 1/8
	9′10″	86	85 5/8	6 3/8	110	2 5/16	3 15/16		3 3/4	3 3/4	3 1/8	2 5/8	2 1/8

NOTE—Connection as shown in full lines for full Housing Fans up to and including 120″. Connection as shown in dotted lines for full Housing Fans over 120″ and all three-quarter Housing Fans.

Heater Case for Buffalo Heaters

Detailed dimensions of the casing used for the Buffalo fan system heaters will be found on page 456. Care should be taken to have the connection between the fan and heater case of such a character that it will not restrict the flow of air or offer unnecessary resistance. This precaution is frequently overlooked, either throwing excessive pressure on the fan, or curtailing the quantity of air handled.

The following table gives the approximate lengths of connection advised for a draw through installation.

LENGTH OF HEATER CONNECTION FOR DRAW THROUGH EQUIPMENT

Size of Fan		Distance From Fan to Heater
Planoidal	Niagara Conoidal	
Up to 70″	Up to No. 7	18″ to 24″
70″ to 100″	7 to 10	24″ to 30″
100″ to 130″	10 to 13	36″
130″ to 170″	13 to 17	42″
170″ to 200″	17 to 20	48″ to 54″

By-Pass Proportions

It is common practice in indirect or fan system heaters to arrange a by-pass, usually beneath the heater, so that all or a part of the air may be taken direct without passing through the heating coils. The by-pass is generally made the full width of the heater with a height of one-third or more of the height of the heater. Since the clear area of the standard Buffalo heater is one-half the gross area, this makes the total area of the by-pass equal to two-thirds or more of the clear area of the heater.

The loss by friction through the by-pass is very slight since the distance the air travels is comparatively short. As ordinarily installed the by-pass is placed below the center of the fan so that the direction of the air is changed more or less several times in going through the by-pass. The loss of entrance and discharge at the by-pass may be taken at from 1½ to 2½ velocity heads, depending on the arrangement. An average loss might be considered as two velocity heads, or approximately the equivalent of the resistance of four Buffalo heater sections of the size to which the by-pass is proportioned. The blast area of the by-pass may be taken as approximately 70 per cent. of the actual area.

Indirect Heaters

This is a special form of pipe coil heater, details and dimensions of which will be found on page 459.

As the table shows, a variety of sizes are built, the smallest being six pipes wide and eight pipes long. Under the heading of "Size," the first row of figures gives the number of pipes across the steam supply and drip ends, and the second column the number of pipes in the length of the coil. Cast iron manifolds are used for the bases into which the pipes are screwed, as in the regular fan system heaters. The indirect heaters may be used in an upright or horizontal position, according to the requirements. These heaters are shown as the solid base type and a diaphragm in same compels the steam to flow evenly through all pipes. The steam supply enters the heater base at one end and the water of condensation is removed directly opposite. These coils are designed for the use of either live or exhaust steam.

Blast Area of Buffalo Heaters

The blast area of any heater may be determined by the formula

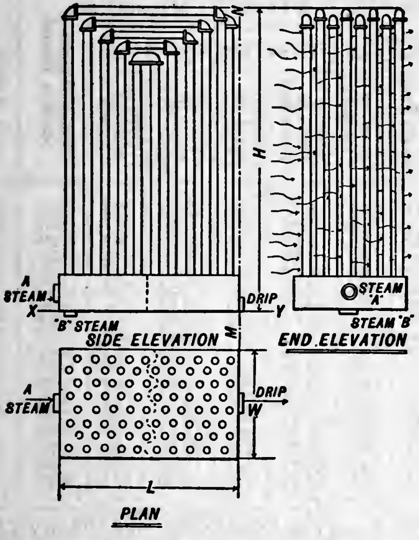
$$A_b = \frac{\text{A. P. M.}}{4005\sqrt{\text{press. drop in in.}}} \qquad (109)$$

Thus, if we assume a case where 10000 cu. ft. of air per minute is to be passed through five sections of Buffalo heater at a velocity of 1000 feet per minute, we find from the table on page 446 that the pressure loss will be 0.479 inch. Then from the above formula

$$\text{Blast area} = \frac{10000}{4005\sqrt{0.479}} = 3.61 \text{ sq. ft.}$$

A general discussion on the subject of blast area, together with an example illustrating the application of the general formula to an entire heating system, will be found on page 126.

INDIRECT HEATERS



ACTUAL LINEAL FEET 1-INCH PIPE IN EACH SECTION

No. Pipes	Size	40½"	46½"	52½"	58½"	64½"	W	L
48	6 x 8	133	154	177	198	221	12½	22
64	6 x 8	177	206	236	265	295	16¼	22
80	8 x 10	221	258	295	332	369	16¼	27
100	10 x 10	276	323	369	415	462	20	27
120	10 x 12	346	387	443	498	553	20	32
140	10 x 14	387	451	517	581	645	20	37
144	12 x 12	398	464	532	598	663	23¼	32
168	12 x 14	464	542	618	697	774	23¼	37
192	12 x 16	532	618	709	798	886	23¼	42
196	14 x 14	542	632	723	814	906	27½	37
256	16 x 16	708	827	945	1061	1181	30¼	42

VENTO CAST IRON HOT-BLAST HEATER
REGULAR SECTION—RATINGS AND FREE AREAS

Regular 40 Inch Section, 10.75 Sq. Ft. Height 41 1/64 Inch. Width 9 1/8 Inch

Number of Loops in Stack	Square Feet of Heating Surface	*Equivalent in Lineal Feet 1-inch Pipe	5" Centers of Loops		5 3/8" Centers of Loops		4 5/8" Centers of Loops		Actual Weight of Stack in Pounds	Approximate Weights
			Standard 44% of Face		52% of Face		37% of Face			
			Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches		
7	75.25	226	4.34	35	5.12	38	3.67	32	594	7.92 lbs. per sq. ft. actual 9 lbs. per sq. ft. shipping weight
8	86.00	258	4.96	40	5.85	43	4.20	37	670	
9	96.75	290	5.58	45	6.57	48	4.72	42	728	
10	107.50	323	6.20	50	7.29	54	5.25	46	851	
11	118.25	355	6.82	55	8.02	59	5.77	51	936	
12	129.00	387	7.44	60	8.74	65	6.30	55	1022	
13	139.75	419	8.06	65	9.47	70	6.82	60	1167	
14	150.50	452	8.68	70	10.19	75	7.35	65	1193	
15	161.25	484	9.30	75	10.91	81	7.87	69	1278	
16	172.00	516	9.92	80	11.64	86	8.40	74	1364	
17	182.75	548	10.54	85	12.36	91	8.92	79	1449	
18	193.50	581	11.16	90	13.09	97	9.45	83	1535	
19	204.25	613	11.78	95	13.82	102	9.97	88	1620	
20	215.00	645	12.40	100	14.54	108	10.50	92	1706	
21	225.75	677	13.02	105	15.26	113	11.02	97	1790	
22	236.50	710	13.64	110	15.98	118	11.55	102	1876	
23	247.25	742	14.26	115	16.71	124	12.07	106	1960	
24	258.00	774	14.88	120	17.43	129	12.60	111	2045	

Regular 50 Inch Section, 13.5 Square Feet. Height 50 29/32 Inch. Width 9 1/8 Inch

			5" Centers		5 3/8" Centers		4 5/8" Centers			
7	94.5	284	5.37	35	6.35	38	4.55	32	717	7.62 lbs. per sq. ft. actual 9 lbs. per sq. ft. shipping weight
8	108.0	324	6.14	40	7.25	43	5.20	37	810	
9	121.5	365	6.91	45	8.15	48	5.85	42	923	
10	135.0	405	7.68	50	9.05	54	6.50	46	1026	
11	148.5	446	8.45	55	9.95	59	7.15	51	1129	
12	162.0	486	9.22	60	10.85	65	7.80	55	1232	
13	175.5	527	9.99	65	11.75	70	8.45	60	1335	
14	189.0	567	10.76	70	12.65	75	9.10	65	1436	
15	202.5	608	11.53	75	13.55	81	9.75	69	1539	
16	216.0	648	12.30	80	14.45	86	10.40	74	1644	
17	229.5	689	13.07	85	15.35	91	11.05	79	1747	
18	243.0	729	13.84	90	16.25	97	11.70	83	1852	
19	256.5	770	14.59	95	17.15	102	12.35	88	1955	
20	270.0	810	15.36	100	18.05	108	13.00	92	2060	
21	283.5	851	16.13	105	18.95	113	13.65	97	2160	
22	297.0	891	16.90	110	19.85	118	14.30	102	2263	
23	310.5	932	17.67	115	20.75	124	14.95	106	2370	
24	324.0	972	18.44	120	21.65	129	15.60	111	2470	

†Note—Add to the width of stack 2 1/2 inches for staggering of stacks.

*Note—The actual length of one-inch pipe per square foot of outside surface is 2.9 lineal feet but is nominally figured at 3 lineal feet, as shown in the third column of above table.

VENTO CAST IRON HOT-BLAST HEATER

REGULAR SECTION—RATINGS AND FREE AREAS

Regular 60 Inch Section, 16 Square Feet. Height 60 11/16 Inch. Width 9 1/8 Inch

Number of Loops in Stack	Square Feet of Heating Surface	*Equivalent in Lineal Feet 1-inch Pipe	5″ Centers of Loops		5 3/8″ Centers of Loops		4 5/8″ Centers of Loops		Actual Weight of Stack in Pounds	Approximate Weights
			Standard 44% of Face		52% of Face		37% of Face			
			Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches		
7	112.0	336	6.45	35	7.62	38	5.47	32	864	7.74 lbs. per sq. ft. actual 9 lbs. per sq. ft. shipping weight
8	128.0	384	7.37	40	8.70	43	6.25	37	988	
9	144.0	432	8.29	45	9.77	48	7.03	42	1112	
10	160.0	480	9.21	50	10.85	54	7.81	46	1238	
11	176.0	528	10.13	55	11.93	59	8.59	51	1362	
12	192.0	576	11.05	60	13.00	65	9.37	55	1486	
13	208.0	624	11.97	65	14.08	70	10.15	60	1610	
14	224.0	672	12.89	70	15.15	75	10.93	65	1734	
15	240.0	720	13.81	75	16.23	81	11.71	69	1858	
16	256.0	768	14.73	80	17.31	86	12.49	74	1982	
17	272.0	816	15.65	85	18.39	91	13.27	79	2106	
18	288.0	864	16.57	90	19.46	97	14.05	83	2230	
19	304.0	912	17.50	95	20.54	102	14.83	88	2352	
20	320.0	960	18.42	100	21.62	108	15.61	92	2478	
21	336.0	1008	19.34	105	22.70	113	16.39	97	2600	
22	352.0	1056	20.26	110	23.78	118	17.17	102	2725	
23	368.0	1104	21.18	115	24.85	124	17.95	106	2850	
24	384.0	1152	22.10	120	25.93	129	18.73	111	2970	

NARROW SECTION—RATINGS AND FREE AREAS

Narrow 40 Inch Section, 7.5 Square Feet. Height 41 1/64 Inch. Width 6 3/4 Inch

			5″ Centers		5 3/8″ Centers		4 5/8″ Centers			
7	52.5	158	4.34	35	5.12	38	3.67	32	420	8.00 lbs. per sq. ft. actual 9.25 lbs. per sq. ft. shipping weight
8	60.0	180	4.96	40	5.85	43	4.20	37	480	
9	67.5	203	5.58	45	6.57	48	4.72	42	540	
10	75.0	225	6.20	50	7.29	54	5.25	46	600	
11	82.5	248	6.82	55	8.02	59	5.77	51	660	
12	90.0	270	7.44	60	8.74	65	6.30	55	720	
13	97.5	293	8.06	65	9.47	70	6.82	60	780	
14	105.0	315	8.68	70	10.19	75	7.35	65	840	
15	112.5	338	9.30	75	10.91	81	7.87	69	900	
16	120.0	360	9.92	80	11.64	86	8.40	74	960	
17	127.5	383	10.54	85	12.36	91	8.92	79	1020	
18	135.0	405	11.16	90	13.09	97	9.45	83	1080	
19	142.5	428	11.78	95	13.82	102	9.97	88	1140	
20	150.0	450	12.40	100	14.54	108	10.50	92	1200	
21	157.5	473	13.02	105	15.26	113	11.02	97	1260	
22	165.0	495	13.64	110	15.98	118	11.55	102	1320	
23	172.5	518	14.26	115	16.71	124	12.07	106	1380	
24	180.0	540	14.88	120	17.43	129	12.60	111	1440	

†NOTE—Add to the width of stack 2 1/2 inches for staggering of stacks.

*NOTE—The actual length of one-inch pipe per square foot of outside surface is 2.9 lineal feet but is nominally figured at 3 lineal feet, as shown in the third column of above table.

VENTO CAST IRON HOT-BLAST HEATER
NARROW SECTION—RATINGS AND FREE AREAS

Narrow 50 Inch Section, 9.5 Square Feet. Height $50\frac{29}{32}$ Inch. Width 6¾ Inch

Number of Loops in Stack	Square Feet of Heating Surface	*Equivalent in Lineal Feet 1" Pipe	5" Centers of Loops		5⅜" Centers of Loops		4⅝" Centers of Loops		Nominal Weight of Stack in Pounds	Actual Weights
			Standard 44% of Face		52% of Face		37% of Face			
			Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches	Net Air Space in Square Feet	†Width of Stack in Inches		
7	66.5	200	5.37	35	6.35	38	4.55	32	515	7.75 lbs. per sq. ft. actual 9.25 lbs. per sq. ft. shipping weight
8	76.0	228	6.14	40	7.25	43	5.20	37	589	
9	85.5	257	6.91	45	8.15	48	5.85	42	663	
10	95.0	285	7.68	50	9.05	54	6.50	46	736	
11	104.5	314	8.45	55	9.95	59	7.15	51	810	
12	114.0	342	9.22	60	10.85	65	7.80	55	883	
13	123.5	371	9.99	65	11.75	70	8.45	60	957	
14	133.0	399	10.76	70	12.65	75	9.10	65	1030	
15	142.5	428	11.53	75	13.55	81	9.75	69	1105	
16	152.0	456	12.30	80	14.45	86	10.40	74	1178	
17	161.5	485	13.07	85	15.35	91	11.05	79	1252	
18	171.0	513	13.84	90	16.25	97	11.70	83	1326	
19	180.5	542	14.59	95	17.15	102	12.35	88	1400	
20	190.0	570	15.36	100	18.05	108	13.00	92	1472	
21	199.5	599	16.13	105	18.95	113	13.65	97	1546	
22	209.0	627	16.90	110	19.85	118	14.30	102	1620	
23	218.5	656	17.67	115	20.75	124	14.95	106	1693	
24	228.0	684	18.44	120	21.65	129	15.60	111	1768	

Narrow 60 Inch Section, 11 Square Feet. Height $60\frac{11}{16}$ Inch. Width 6¾ Inch

			5" Centers		5⅜" Centers		4⅝" Centers			
7	77.0	231	6.45	35	7.62	38	5.47	32	604	7.85 lbs. per sq. ft. actual 9.25 lbs. per sq. ft. shipping weight
8	88.0	264	7.37	40	8.70	43	6.25	37	691	
9	99.0	297	8.29	45	9.77	48	7.03	42	777	
10	110.0	330	9.21	50	10.85	54	7.81	46	864	
11	121.0	363	10.13	55	11.93	59	8.59	51	950	
12	132.0	396	11.05	60	13.00	65	9.37	55	1037	
13	143.0	429	11.97	65	14.08	70	10.15	60	1123	
14	154.0	462	12.89	70	15.15	75	10.93	65	1210	
15	165.0	495	13.81	75	16.23	81	11.71	69	1295	
16	176.0	528	14.73	80	17.31	86	12.49	74	1382	
17	187.0	561	15.65	85	18.39	91	13.27	79	1469	
18	198.0	594	16.57	90	19.46	97	14.05	83	1555	
19	209.0	627	17.50	95	20.54	102	14.83	88	1641	
20	220.0	660	18.42	100	21.62	108	15.61	92	1727	
21	231.0	693	19.34	105	22.70	113	16.39	97	1813	
22	242.0	726	20.26	110	23.78	118	17.17	102	1900	
23	253.0	759	21.18	115	24.85	124	17.95	106	1985	
24	264.0	792	22.10	120	25.93	129	18.73	111	2072	

†NOTE—Add to the width of stack 2½ inches for staggering of stacks.

*NOTE—The actual length of one-inch pipe per square foot of outside surface is 2.9 lineal feet but is nominally figured at 3 lineal feet, as shown in the third column of above table.

Determination of Guarantees

The case often arises that a guarantee to heat a building to a certain specified temperature must be demonstrated at a time when the outside temperature is much higher than called for in the guarantee. It then becomes important to know the exact relation between the increase in outside and inside temperature when apparatus is operated to its full capacity. This relation has been published for heating with direct radiation, but it varies considerably from the results obtained with the fan system. Naturally the rise in indoor temperature will be less than the rise in outdoor temperature owing to the fact that the condensing capacity has been shown to be directly proportional to the difference in temperature between steam and air, while with direct radiation it is not directly proportional owing to the variation in convection currents. The same relation between indoor and outdoor temperature may be shown to hold true whether the system was designed to take the air from outdoors entirely or to recirculate air within the building. The formula expressing the relation between indoor and outdoor temperature in either case is:

$$t_r = \frac{t_r'(t_s - t_1) + t_s(t_1 - t_1')}{t_s - t_1'} \qquad (110)$$

When the guarantee is based on an outside temperature of 0° the formula becomes

$$t_r = \frac{t_r'(t_s - t_1) + t_s \times t_1}{t_s} \qquad (111)$$

t_r = temperature of building obtained with outside temperature t_1.
t_1 = any outside temperature at which test is made.
t_r' = temperature of building guaranteed.
t_1' = specified outside temperature.
t_s = temperature of steam at pressure specified.

The table on page 464 gives corresponding indoor temperatures as derived from equation above for various outdoor temperatures with guarantees at 60° to 95° in zero weather.

The table on page 465 giving mean monthly temperatures in different localities will be found useful in many instances in laying out heating systems.

TABLE OF AVERAGE INDOOR TEMPERATURES MAINTAINED AT VARIOUS OUTDOOR TEMPERATURES WITH 5 LBS. STEAM PRESSURE

Outdoor Temp.	Average Indoor Temperatures Deg. Fahr.							
–20	45.2	50.8	56.1	61.6	67.1	72.5	77.9	83.4
–15	48.9	54.3	59.7	64.9	70.3	75.6	80.9	87.3
–10	52.9	57.9	63.1	68.3	73.5	78.7	86.0	89.2
–5	56.3	61.4	66.5	71.6	76.8	81.9	87.0	92.1
0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0
5	63.7	68.6	73.5	78.4	83.2	88.1	93.0	97.9
10	67.4	72.1	76.9	81.7	86.5	91.3	96.0	100.8
15	71.0	75.7	80.3	85.1	89.7	94.4	99.1	103.7
20	74.7	79.3	83.9	88.4	92.9	97.5	102.1	106.6
25	78.4	82.9	87.3	91.8	96.2	100.7	105.1	109.5
30	82.1	86.4	90.8	94.1	99.4	103.8	108.1	112.4
35	85.8	90.0	94.3	97.5	102.6	106.9	111.2	115.3
40	89.4	93.6	97.7	101.8	105.9	110.0	114.2	118.2
45	93.1	97.1	101.2	105.4	109.1	113.2	117.2	121.1
50	96.8	100.7	104.7	108.5	112.4	116.3	120.2	124.0
55	100.5	104.3	108.1	111.9	115.6	119.4	123.3	126.9
60	104.2	107.8	111.6	115.2	118.8	122.6	126.3	129.8
65	107.8	111.4	115.0	118.6	122.1	125.7	129.3	132.7
70	111.5	115.0	118.5	121.9	125.3	128.8	132.4	135.6

MEAN MONTHLY TEMPERATURES IN DIFFERENT LOCALITIES

	Portland, Ore.	St. Louis, Mo.	St. Paul, Minn.	Atlanta, Ga.	Philadelphia, Pa.	Boston, Mass.	Portland, Me.	Chicago, Ill.	New York, N. Y.
January	38.7	31.0	11.9	42.2	31.8	27.0	22.0	24.0	30.6
February	41.4	33.5	15.4	45.2	32.8	28.0	23.8	25.7	30.7
March	46.1	43.5	28.2	52.4	40.0	35.0	32.0	34.9	37.8
April	51.8	56.1	45.8	61.1	50.8	45.3	43.0	46.2	48.7
May	57.7	66.5	57.7	69.5	62.2	56.6	53.5	56.6	59.8
June	62.5	75.1	67.2	75.6	71.2	65.8	62.6	66.5	69.0
July	67.3	79.1	72.0	77.6	75.8	71.3	68.0	72.3	74.1
August	66.6	77.2	69.7	76.1	73.8	68.9	66.2	71.3	72.6
September	61.3	70.0	60.5	72.1	67.4	62.7	59.6	64.8	66.5
October	53.7	58.4	48.4	62.4	56.3	52.3	49.1	53.1	55.6
November	45.7	43.4	31.0	51.9	44.9	41.2	37.6	39.4	43.9
December	40.2	35.5	18.8	44.6	35.7	31.6	27.1	29.1	36.0
Mean for year	52.8	55.8	43.9	60.9	53.6	48.8	45.4	48.7	52.1
Mean during heating season	49.9	43.1	35.4	51.4	44.4	42.3	41.1	41.5	43.0
Difference between 70° and mean during heating months	25.7	28.5	39.0	22.0	28.3	30.4	32.3	32.0	28.8
Number of days during heating season	203	178	223	139	190	216	234	212	197
Per cent. of New York City heating requirements	92	90	154	54	95	116	133	119	100

E. F. Tweedy in "Power," June 16, 1912.

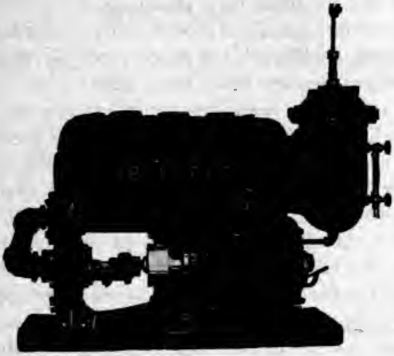
BUFFALO DUPLEX AUTOMATIC FEED PUMPS AND RECEIVERS

The unit consists of a suitably constructed cast iron receiving tank, mounted in combination with a Boiler Feed Pump on a common bed plate. The tank is mounted slightly above the pump, giving a sufficient head of water above the suction valves to insure the pump always receiving a full supply of water.

Within the tank is provided a float connected to a chronometer valve controlling the steam supply to the pump. Inflowing water causes float to rise, thereby opening the steam supply and starting the pump. When the water level has been lowered, the float automatically cuts off the steam. In this way the condensation water is returned to the boiler as fast as it accumulates.

Diameter Steam Cylinders	Diameter Water Pistons	Length of Stroke	Pump Capacity Gallons per Minute	Square Feet Direct Radiation Apparatus will Drain	Lineal Feet of 1-Inch Pipe Fan System Heater Apparatus Will Drain	Minimum Lbs. Steam Pressure Recommended
With Standard Boiler Feed Pumps						
3	2	3½	10	5000	2500	50
4½	2¾	4	20	10000	5000	40
5¼	3½	5	40	20000	10000	35
5¼	3½	6	45	25000	12500	35
6	4	6	60	40000	20000	35
7	4	8	80	50000	25000	30
7½	4½	8	100	60000	30000	30
With Low Steam Pressure Pumps						
3	1½	3½	6	3000	1500	35
4½	2	4	11	6000	3000	25
6	2	6	16	9000	4500	10
7½	2½	6	25	15000	7500	10

BUFFALO CENTRIFUGAL AUTOMATIC FEED PUMPS AND RECEIVERS



Centrifugal Pumps and Receivers are designed primarily for returning condensation from low-pressure systems into boilers, especially where steam pressure is so low as to prevent using reciprocating steam pumps. Centrifugal pumps should be especially designed for handling hot water and equipped with enclosed type polished brass runners or impellers. Receivers should be cast iron or similar material, strong enough to stand 50 pounds pressure. Centrifugal pumps are ordinarily equipped with 40 gallon receivers but smaller size receivers can be used if desired. Larger size receivers are not desirable, as the accumulated water should be returned to boiler as promptly as possible before it loses temperature.

The general method of operation of all electric driven pumps and receivers is the same. The condensation collects in receiver tank, raising large seamless copper float, until at a maximum point the float, by its connection, closes the float-switch, and an automatic starter starts the motor driving the pump. As the pump drains the receiver the float falls, until at a minimum point the float-switch is opened and the motor stops.

In determining proper size outfit to use it is necessary to know amount of radiation, boiler pressure, lift and pipe friction to boiler and details of electric current. On low steam pressure outfits about 30 per cent. margin should be allowed in figuring power, as water at 10 pounds pressure cannot be forced into a boiler carrying 10 pounds steam pressure.

GAS HEATERS

Various forms of heaters have been devised for use in connection with fans, utilizing the heat of the gases direct rather than through the medium of a steam boiler.

The efficiency of a gas-fired steam boiler, according to tests by Jay M. Whitman, is seldom in excess of 65 to 70 per cent. Some forms of gas heaters have been short-lived, no provision having been made to prevent temperatures in the heating surfaces so high as to destroy them in one or two heating seasons. To be reasonably long-lived, the heat must be transmitted from gas to air through surfaces which are not exposed to temperatures above 1200° F., and the construction must permit the renewal of this heating surface at least as conveniently as in the case of a boiler. These requirements can best be met by a design in which the heating surface proper consists of boiler tubes expanded into heads, the gases passing through the tubes, and the air drawn across them by the fan, while for best economy the range of temperature for the gases is from 1200° to 400° F. With natural gas or producer gas fuel, this design of heater has been combined with a combustion chamber provided with fire brick checker work, which, becoming incandescent, provides for the complete combustion of the mixture of gas and air before it leaves the chamber; a mixing chamber in which the high temperature products of combustion are mixed with low temperature gases which have already passed through the heater, and which in any desired proportion may be recirculated by an induced draft fan; an exhaust chamber from which the induced draft fan draws the cooled gases, part of which are discharged and part recirculated, and a suitable setting with boiler fronts and inspection doors, so as to make the various chambers accessible.

With natural gas having a calorific value of 1000 B. t. u., the loss in the waste gases discharged at 400° is approximately 60 B. t. u., corresponding to an efficiency of 94 per cent. When running at part load, and allowing for possible poor regulation of the burners, such a heater still has an efficiency better than a good steam boiler. Where producer gas is available instead of natural gas, similar economy will be shown. The high temperature exhaust from gas engines, if of sufficient volume and regular in quantity, waste gases from furnaces, or even under some conditions from boiler plants, may be utilized to good advantage.

SECTION VI

AIR CONDITIONING APPARATUS

Air Washers

Air washers are generally used in connection with ventilating systems for public buildings, offices and residences. Their efficiency in purifying the air varies greatly with their construction and also depends in a large measure upon the nature and quantity of the impurities in the air to be washed. In general, the heavier particles in the air, such as street dust for instance, are comparatively easy to remove even with a washer of simple construction. On the other hand, the very fine particles often existing in city air, especially where it is taken some distance from the ground, where the impurities consist chiefly of fine ash and smoke particles, are exceedingly difficult to remove, and the most efficient air washer construction is required to get satisfactory results, or in fact, any results which will be worth the cost of installing an air washing device.

Principles of Air Washer Construction

It has been found by experiment, and is now generally acknowledged by engineers, that in washing air or gas the first essential is to fill the chamber through which it is passed with a finely divided spray or mist in order to get as great a contact surface as possible between the water and air and to secure a thorough mixture. Probably the most satisfactory way of accomplishing this is by the use of a large number of uniformly spaced centrifugal nozzles with large orifices to prevent clogging with foreign material. It has been found practicable to use orifices $\frac{3}{16}$-inch in diameter in centrifugal nozzles which will give a satisfactory division and distribution of spray and at the same time will not clog. The nozzles should spray in the direction of the air flow.

An adequate filtering system should be provided, where the water is recirculated, in order to remove any large obstructions that might otherwise enter the spray system.

NOTE.—For a general discussion on the subject of Humidity, see page 28; and on Air Washing, Cooling, Humidifying and Drying, see page 67.

The velocity through the washer for best results should be between 400 and 500 feet per minute. It is equally important that the air be distributed uniformly over the entire area of the washer. This is often difficult to accomplish and can only be secured by means of a diffuser or distributing plate at the washer inlet.

While some work may be done with a finely divided spray, it cannot be depended upon alone to give satisfactory cleaning effect. The air after having been moistened must be brought into repeated contact with wetted surfaces and subjected to the combined action of impact and centrifugal force. For the best results, the air should also be divided and broken up into as narrow layers or strata as may be possible mechanically, in order, 1st, that as great a contact surface may be secured as possible, and 2nd, that the solid particles contained in the air shall have as small a distance to travel as possible before coming into contact with a wetted surface where they will be entrained. This is best accomplished by placing in the eliminators large, independently flooded vertical surfaces. The plates forming this flooded surface should be placed as closely as possible, preferably about 1 inch apart, arranged vertically and flooded from the top. An extension of these surfaces should be provided with lips for the removal of all traces of free moisture. A satisfactory ratio has been found to be 64 sq. ft. of combined washing and eliminating surface per 1000 cu. ft. of air per minute.

In public building work provision should be made for heating the spray water and controlling the moisture content of the air in cold weather. The simplest method of accomplishing this is to regulate the temperature of the air leaving the washer by means of a thermostat, at the same time saturating the air by means of a heated spray at a variable temperature.

Air conditioning apparatus for controlling the humidity of air for manufacturing processes may be broadly classified, according to use, into humidifiers proper, which add moisture to the air in required amounts; and dehumidifiers, which remove a variable quantity of moisture from the air to reduce it to the required standard. The relative humidity of the air may also be altered, and in a measure regulated, simply by changing its temperature without affecting its moisture contents.

Types of Humidifiers

Humidifiers may be classified into the spray and evaporative types, the latter being divided again into direct and indirect. The humidity of the air may also be increased by the direct introduction of steam into the air supply or into the room. Since the total heat of the vapor at atmospheric temperature is somewhat less than the total heat at steam temperature, this raises the temperature of the air perceptibly and is therefore intolerable in the majority of cases. Added objections to the direct use of steam are that it frequently gives a noticeable odor and that it is difficult to regulate. The spray and evaporative types of humidifiers have a distinct value aside from humidifying in their possession of a cooling effect which is in direct proportion to their moistening effect. The direct spray type of humidifier is distinguished from the evaporative type in that it introduces a finely divided or atomized spray directly into the room in constant volume, while the evaporative type introduces only the water vapor. There is also a mixed type which discharges both moist air and free moisture into the room.

In what may be termed the indirect evaporative humidifier the air is partly or entirely taken from the outside and is humidified and conditioned before it is introduced into the room. In the direct evaporative type the water vapor passes directly into the air of the room. The indirect system of air conditioning is also termed the central system, and is known commercially as the Carrier System.

The Dehumidifier

In the dehumidifier, relatively cold spray water is used to condense the moisture out of the air. The water is either refrigerated or taken from an artesian well. When the water is artificially cooled the refrigerating coils are usually placed in a chamber underneath the spray chamber, and the water is so distributed as to flow uniformly over the cold surface, dropping to the tank underneath. The dehumidifier has its sprays opposed to the direction of air flow as in the humidifier, but differs from the latter in having usually two sets of sprays in series instead of one. Two or more dehumidifiers are frequently placed in series when the range of air temperature is great or when an economy of cooling water is essential.

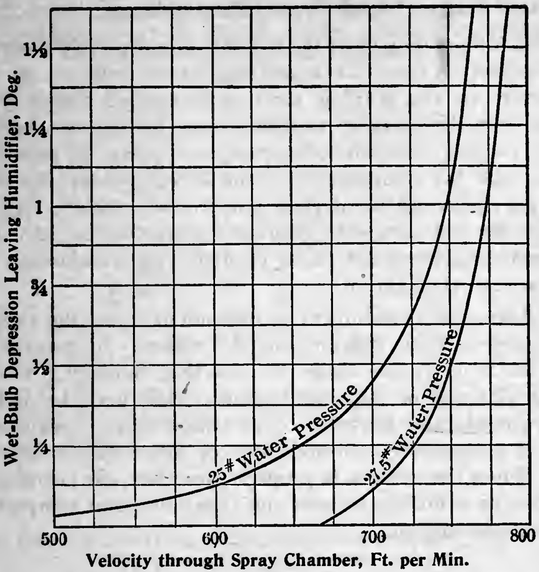
Elements of Design of Humidifiers

The degree of saturation of the air leaving any type of air washer or humidifier depends upon the intimacy of the contact of the air and water, and upon the relation of the water temperature to the wet-bulb temperature of the entering air. It also depends to some degree upon the length of the spray chamber as well as upon the velocity of the air passing through it.

The size of the nozzle orifice is also a very important factor in determining the degree of saturation obtained. In general, the smaller the nozzle orifice the more perfect will be the humidifying effect with a given quantity of water. For humidifiers it is standard practice to use centrifugal nozzles having a 3-32 inch orifice, and where rotary strainers are employed for filtering the spray water the nozzle orifice may be reduced to 1-16 inch in diameter to advantage.

With the centrifugal type of spray nozzles the water pressure is a most important element affecting the degree of saturation. The accompanying diagram shows the humidifying effect secured with various velocities and at different pressures on the spray nozzle, in a standard humidifier having four 3-32 inch orifice centrifugal spray nozzles per square foot. This data was obtained from a test in which the wet-bulb depression of the entering air was maintained constant at 16°. It will be noted that an increase of 2½ pounds in the spray pressure permitted a greatly increased velocity with perfect saturation, an effect which was undoubtedly due to the increased fineness of the spray rather than to the increase in the amount of water discharged. In this test, as in all standard humidifiers, the water was discharged in the direction opposite the air flow, increasing the efficiency of saturation.

When the spray water is recirculated without heating, as in warm weather, it remains at all times substantially at the wet-bulb temperature of the entering air, while the wet-bulb temperature of the air leaving the washer or dehumidifier is unchanged; therefore it follows in conformance with the theory, that when the air is completely saturated as in the humidifier the air is cooled to the wet-bulb temperature of the incoming air. This cooling effect is due to evaporation and is therefore in direct proportion to the moisture added to the air. The wet-bulb depression in atmospheric air averages from 12° to 15° in summer,



while occasionally a depression of 20° to 30° is found in extremely hot and dry weather. In every case a properly designed humidifier will cool the incoming air a corresponding number of degrees.

When saturation is incomplete, as in the ordinary air washer, the wet-bulb depression of the air leaving the washer is found to be a constant percentage of the initial wet-bulb depression, when the air velocity remains constant.

It follows that the cooling effect is a constant percentage of the initial wet-bulb depression. This may be expressed by the formulae

$$\frac{t_2 - t'}{t_1 - t'} = R$$

$$\frac{t_1 - t_2}{t_1 - t'} = 1 - R = E$$

where

t' = constant wet-bulb temperature.
t_1 = temperature of air entering washer.
t_2 = temperature of air leaving washer.
R = constant ratio depending upon intimacy of contact, air velocity, etc.
E = efficiency of saturation.

Elements of Design of Spray Type of Dehumidifiers

Dehumidifiers may be of the spray type previously described, or of the surface type. A knowledge of the relation of water temperature to the leaving air temperature in either type is essential. In the spray type of one stage having two banks of opposed nozzles, the air temperature leaving is practically identical with the temperature of the leaving water, the difference never exceeding one degree in a properly designed apparatus. The air will always be saturated when leaving and under some conditions there is a slight tendency to entrainment even after thorough elimination.

The degree of entrainment is dependent upon the range of temperature of both the air and the water. In general, the smaller the temperature range, the less the tendency is to moisture entrainment or supersaturation. This may be reduced where a considerable lowering of air temperature is required by passing it successively through two or more dehumidifiers in series. When the system is properly designed, the entrainment should not be sufficient to raise the true dew-point temperature more than one degree.

Refrigeration Required for Dehumidifying

The heat to be removed in cooling a known weight of air from a given temperature and moisture content to a given dew-point temperature, is evidently the difference of the total heat quantities contained in the air under these respective conditions. These values of total heat are given on the charts on pages 36 and 37. It is there shown that the total of latent and specific heat in one pound of pure air is dependent upon the wet-bulb temperature only. The upper table on page 475 shows the amount of refrigeration required to cool and dehumidify 1000 cu. ft. of air between various given wet-bulb temperatures and final dew-points.

Power Required for Operating Humidifiers

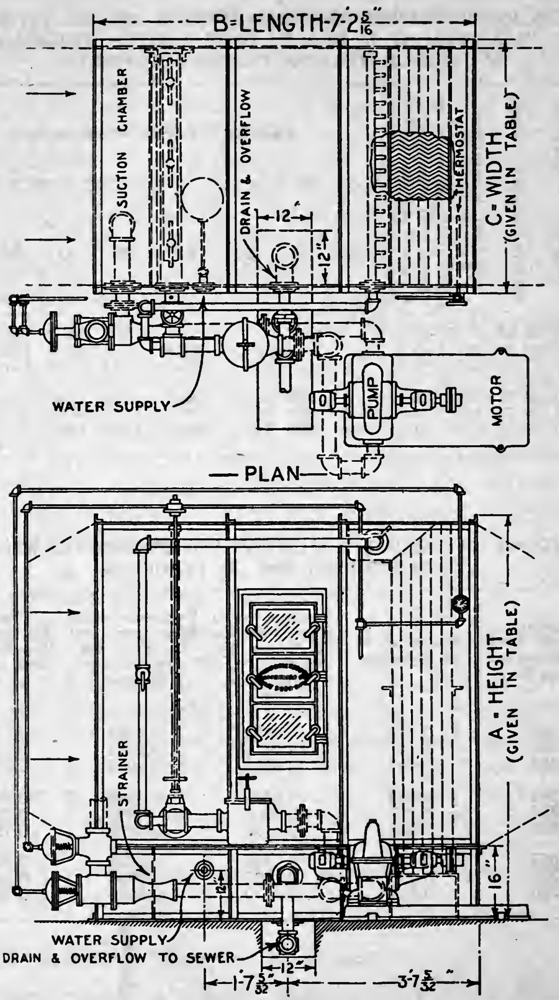
The lower table on page 475 exhibits the power required to saturate 1000 cu. ft. of air per minute at various velocities. This is based on overcoming the resistance of the humidifier, using a fan with a static efficiency of 45 per cent., a fair value.

B. T. U. REFRIGERATION REQUIRED TO COOL 1000 CU. FT. OF AIR (MEASURED AT 70 DEG. F.) FROM A GIVEN WET-BULB TEMPERATURE TO A GIVEN DEW-POINT

Leaving Dew-Point	Ammonia Temperature	Suction Pressure (Gauge)	Per Cent. Compressor Ratings at 15 Lb.	Per Cent. Horsepower Compared with Horsepower Required at Rated Suction Pressure of 15 Lb. Gauge	Entering Wet-Bulb Temperature							
					50	55	60	65	70	75	80	85
65	45	65.96	270	41.5					296	606	961	1350
60	40	58.29	244	45.5				259.0	553	865	1220	1609
55	35	51.22	220	49.5			221.5	480.5	777	1086	1440	1840
50	30	44.72	199	54.5		203	425.0	683.0	980	1290	1570	2030
45	25	38.73	182	59.5	185	388	611.0	869.0	1165	1474	1830	2220
40	20	33.25	164	66.0	359	569	791.0	1050.0	1345	1656	2010	2400

RESISTANCE OF CARRIER HUMIDIFIERS AND HORSEPOWER REQUIRED TO HUMIDIFY 1000 CU. FT. OF AIR

Velocity Through Spray Chamber in Ft. per Min.	Resistance in In. of Water	Horsepower to Move 1000 Cu. Ft. Air per Min. at 45% Fan Efficiency	Horsepower for Spray per 1000 Cu. Ft. of Air (1/16 Orifice Nozzle)	Total Horsepower Required per 1000 Cu. Ft. of Air
350	0.112	0.0391	0.1408	0.1799
400	0.147	0.0513	0.1231	0.1744
450	0.186	0.0652	0.1095	0.1747
500	0.229	0.0800	0.0985	0.1785
550	0.277	0.0968	0.0897	0.1865
600	0.330	0.1150	0.0822	0.1972
650	0.387	0.1350	0.0758	0.2108
700	0.450	0.1570	0.0704	0.2274
750	0.516	0.1810	0.0658	0.2468

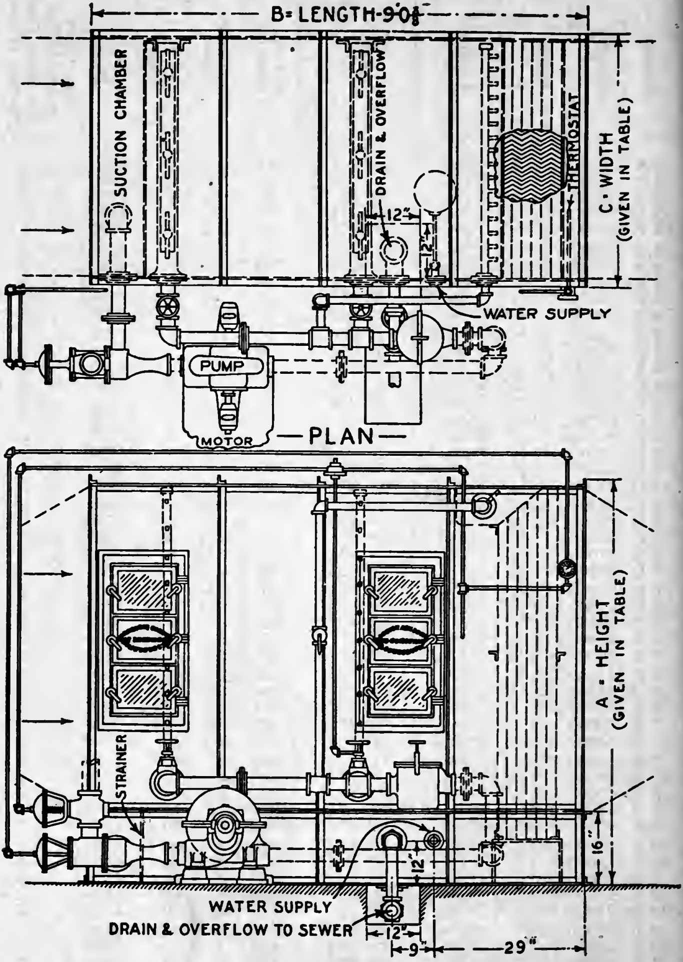


Carrier Type "A" Washer

DIMENSIONS FOR CARRIER TYPE "A" AIR WASHERS

Number	Capacity in C. F. M.	Height A	Length B	Width C	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor	Size Water Supply Inches	Size Sewer Connection Inches
1 A	1500	4′1½″	7′2 5/16″	1′ 5¼″	14	1½	2	1700	¾	2
1 B	2100	5′1½″	7′2 5/16″	1′ 5¼″	16	1½	2	1700	¾	2
2 A	3100	4′1½″	7′2 5/16″	2′ 9″	28	1½	2	1700	¾	2
1 C	3200	7′1½″	7′2 5/16″	1′ 5¼″	23	1½	2	1700	¾	2
2 B	4400	5′1½″	7′2 5/16″	2′ 9″	32	1½	2	1700	¾	2
3 A	4800	4′1½″	7′2 5/16″	4′ 0¾″	42	1½	2	1700	¾	2
4 A	6400	4′1½″	7′2 5/16″	5′ 4½″	56	1½	3	1700	¾	2
3 B	6700	5′1½″	7′2 5/16″	4′ 0¾″	48	1½	2	1700	¾	2
2 C	6900	7′1½″	7′2 5/16″	2′ 9″	46	1½	2	1700	¾	2
4 B	9000	5′1½″	7′2 5/16″	5′ 4½″	63	1½	3	1700	¾	2
2 D	9400	9′1½″	7′2 5/16″	2′ 9″	57	1½	3	1700	¾	2
3 C	10500	7′1½″	7′2 5/16″	4′ 0¾″	69	1½	3	1700	¾	2
5 B	11300	5′1½″	7′2 5/16″	6′ 8″	79	2	3	1700	¾	2
4 C	14100	7′1½″	7′2 5/16″	5′ 4½″	92	2	3	1700	¾	2
3 D	14300	9′1½″	7′2 5/16″	4′ 0¾″	85	2	3	1700	¾	2
5 C	17700	7′1½″	7′2 5/16″	6′ 8″	115	2	5	1700	¾	2
3 E	18100	11′1¾″	7′2 5/16″	4′ 1¼″	102	2	5	1700	¾	2
4 D	19200	9′1½″	7′2 5/16″	5′ 4½″	114	2	5	1700	¾	2
6 C	21300	7′1½″	7′2 5/16″	7′11¾″	139	2½	5	1700	¾	2
5 D	24100	9′1½″	7′2 5/16″	6′ 8″	142	2½	5	1700	¾	2
4 E	24300	11′1¾″	7′2 5/16″	5′ 5″	135	2½	5	1700	¾	2
6 D	29000	9′1½″	7′2 5/16″	7′11¾″	171	2½	5	1700	¾	2
4 F	29400	13′1¾″	7′2 5/16″	5′ 5″	164	2½	5	1700	¾	2
5 E	31000	11′1¾″	7′2 5/16″	6′ 8½″	169	2½	5	1700	¾	2
7 D	33900	9′1½″	7′2 5/16″	9′ 3½″	200	2½	7½	1700	¾	2
6 E	36700	11′1¾″	7′2 5/16″	8′ 0¼″	204	2½	7½	1700	¾	2
5 F	37000	13′1¾″	7′2 5/16″	6′ 8½″	205	2½	7½	1700	¾	2
8 D	38800	9′1½″	7′2 5/16″	10′ 7¼″	228	3	7½	1700	¾	2
7 E	42900	11′1¾″	7′2 5/16″	9′ 4″	238	3	7½	1700	¾	2
9 D	43700	9′1½″	7′2 5/16″	11′11″	256	3	7½	1700	1	2
6 F	44500	13′1¾″	7′2 5/16″	8′ 0¼″	247	3	7½	1700	¾	2
10 D	48600	9′1½″	7′2 5/16″	13′ 2½″	286	3	7½	1700	1	2
8 E	49100	11′1¾″	7′2 5/16″	10′ 7¾″	271	3	7½	1700	¾	2
7 F	52000	13′1¾″	7′2 5/16″	9′ 4″	288	3	7½	1700	¾	2
11 D	53500	9′1½″	7′2 5/16″	14′ 6¼″	315	4	10	1120	1	2
9 E	55000	11′1¾″	7′2 5/16″	11′11½″	305	4	10	1120	1	2
12 D	59000	9′1½″	7′2 5/16″	15′10″	343	4	10	1120	1	2
8 F	60000	13′1¾″	7′2 5/16″	10′ 7¾″	329	4	10	1120	¾	2
7 G	61000	15′2″	7′2 5/16″	9′ 4½″	326	4	10	1120	¾	2
10 E	62000	11′1¾″	7′2 5/16″	13′ 3″	340	4	10	1120	1	2
9 F	67000	13′1¾″	7′2 5/16″	11′11½″	370	4	10	1120	1	2
11 E	68000	11′1¾″	7′2 5/16″	14′ 6¾″	374	4	10	1120	1	2
8 G	70000	15′2″	7′2 5/16″	10′ 8¼″	373	4	10	1120	¾	2
12 E	74000	11′1¾″	7′2 5/16″	15′10½″	408	4	10	1120	1	2
10 F	75000	13′1¾″	7′2 5/16″	13′ 3″	412	4	10	1120	1	2
9 G	79000	15′2″	7′2 5/16″	12′ 0″	419	4	10	1120	1	2
13 E	80000	11′1¾″	7′2 5/16″	17′ 2¼″	442	4	10	1120	1	3
11 F	82000	13′1¾″	7′2 5/16″	14′ 6¾″	453	5	15	1120	1	3
14 E	87000	11′1¾″	7′2 5/16″	18′ 6″	477	4	15	1120	1	3
10 G	88000	15′2″	7′2 5/16″	13′ 3½″	466	4	15	1120	1	2

Additional sizes and capacities on request.



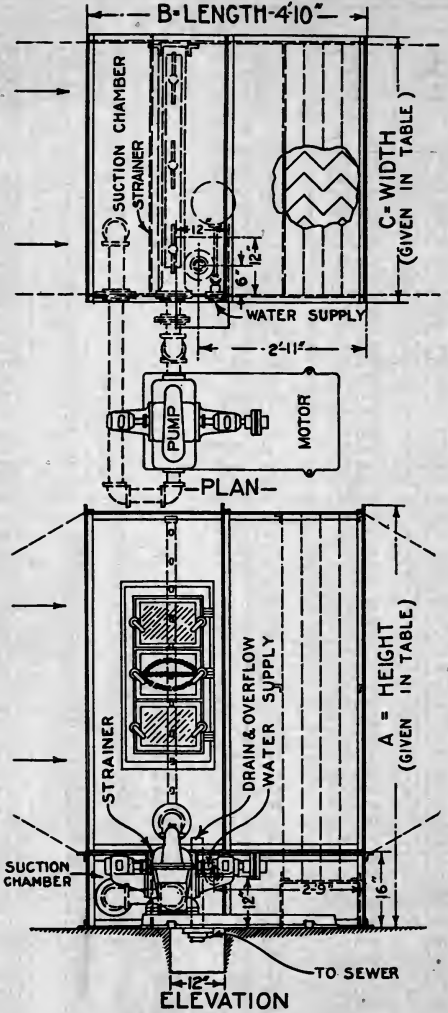
ELEVATION

Carrier Type "B" Washer

DIMENSIONS FOR CARRIER TYPE "B" AIR WASHERS

Number	Capacity in C. F. M.	Height A	Length B	Width C	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor	Size Water Supply Inches	Size Sewer Connection Inches
1 A	1500	4'1½"	9'0⅜"	1' 5¼"	23	1½	2	1700	¾	2
1 B	2100	5'1½"	9'0⅜"	1' 5¼"	27	1½	2	1700	¾	2
2 A	3100	4'1½"	9'0⅜"	2' 9"	46	1½	2	1700	¾	2
1 C	3200	7'1½"	9'0⅜"	1' 5¼"	41	1½	2	1700	¾	2
2 B	4400	5'1½"	9'0⅜"	2' 9"	54	1½	3	1700	¾	2
3 A	4800	4'1½"	9'0⅜"	4' 0¾"	69	1½	3	1700	¾	2
4 A	6400	4'1½"	9'0⅜"	5' 4½"	92	2	3	1700	¾	2
3 B	6700	5'1½"	9'0⅜"	4' 0¾"	81	2	3	1700	¾	2
4 C	6900	7'1½"	9'0⅜"	2' 9"	82	2	3	1700	¾	2
4 B	9000	5'1½"	9'0⅜"	5' 4½"	106	2	5	1700	¾	2
2 D	9400	9'1½"	9'0⅜"	2' 9"	104	2	5	1700	¾	2
3 C	10500	7'1½"	9'0⅜"	4' 0¾"	123	2	5	1700	¾	2
5 B	11300	5'1½"	9'0⅜"	6' 8"	133	2½	5	1700	¾	2
4 C	14100	7'1½"	9'0⅜"	5' 4½"	164	2½	5	1700	¾	2
3 D	14300	9'1½"	9'0⅜"	4' 0¾"	155	2½	5	1700	¾	2
5 C	17700	7'1½"	9'0⅜"	6' 8"	205	2½	7½	1700	¾	2
3 E	18100	11'1¾"	9'0⅜"	4' 1¼"	189	2½	5	1700	¾	2
4 D	19200	9'1½"	9'0⅜"	5' 4½"	208	2½	7½	1700	¾	2
6 C	21300	7'1½"	9'0⅜"	7'11¾"	247	3	7½	1700	1	2
5 D	24100	9'1½"	9'0⅜"	6' 8"	259	3	7½	1700	¾	2
4 E	24300	11'1¾"	9'0⅜"	5' 5"	250	3	7½	1700	¾	2
6 D	29000	9'1½"	9'0⅜"	7'11¾"	311	4	10	1120	1	2
4 F	29400	13'1¾"	9'0⅜"	5' 5"	308	4	10	1120	¾	2
5 E	31000	11'1¾"	9'0⅜"	6' 8½"	313	4	10	1120	¾	2
7 D	33900	9'1½"	9'0⅜"	9' 3½"	364	4	10	1120	1	2
6 E	36700	11'1¾"	9'0⅜"	8' 0¼"	347	4	10	1120	1	2
5 F	37000	13'1¾"	9'0⅜"	6' 8½"	385	4	10	1120	¾	2
8 D	38800	9'1½"	9'0⅜"	10' 7¼"	415	4	10	1120	1	2
7 E	42900	11'1¾"	9'0⅜"	9' 4"	440	4	10	1120	1	2
9 D	43700	9'1½"	9'0⅜"	11'11"	466	4	15	1120	1	2
6 F	44500	13'1¾"	9'0⅜"	8' 0¼"	463	4	15	1120	1	2
10 D	48600	9'1½"	9'0⅜"	13' 2½"	520	4	15	1120	1	2
8 E	49100	11'1¾"	9'0⅜"	10' 7¾"	501	4	15	1120	1	2
7 F	52000	13'1¾"	9'0⅜"	9' 4"	540	5	15	1120	1	2
11 D	53500	9'1½"	9'0⅜"	14' 6¼"	573	5	15	1120	1¼	2
9 E	55000	11'1¾"	9'0⅜"	11'11½"	564	5	15	1120	1	2
12 D	59000	9'1½"	9'0⅜"	15'10"	624	5	15	1120	1¼	2
8 F	60000	13'1¾"	9'0⅜"	10' 7¾"	617	5	15	1120	1	2
7 G	61000	15'2"	9'0⅜"	9' 4½"	616	5	15	1120	1	2
10 E	62000	11'1¾"	9'0⅜"	13' 3"	628	5	15	1120	1	2
9 F	67000	13'1¾"	9'0⅜"	11'11½"	694	5	15	1120	1	2
11 E	68000	11'1¾"	9'0⅜"	14' 6¾"	691	5	15	1120	1¼	2
8 G	70000	15'2"	9'0⅜"	10' 8¼"	707	5	15	1120	1	2
12 E	74000	11'1¾"	9'0⅜"	15'10½"	754	5	15	1120	1¼	2
10 F	75000	13'1¾"	9'0⅜"	13' 3"	772	5	20	1120	1	2
9 G	79000	15'2"	9'0⅜"	12' 0"	792	5	20	1120	1	2
13 E	80000	11'1¾"	9'0⅜"	17' 2¼"	817	6	20	1120	1¼	3
11 F	82000	13'1¾"	9'0⅜"	14' 6¾"	849	6	20	1120	1¼	3
14 E	87000	11'1¾"	9'0⅜"	18' 6"	881	6	20	1120	1¼	3
10 G	88000	15'2"	9'0⅜"	13' 3½"	880	6	20	1120	1	2

Additional sizes and capacities on request.



Carrier Type "C" Washer

DIMENSIONS FOR CARRIER TYPE "C" AIR WASHERS

Number	Capacity in C. F. M.	Height A	Length B	Width C	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor
1 A	1700	4′1½″	4′10″	1′ 5¼″	9	1½	2	1700
1 B	2300	5′1½″	4′10″	1′ 5¼″	11	1½	2	1700
1 C	3400	7′1½″	4′10″	1′ 5¼″	18	1½	2	1700
2 A	3500	4′1½″	4′10″	2′ 9″	18	1½	2	1700
2 B	4800	5′1½″	4′10″	2′ 9″	22	1½	2	1700
3 A	5400	4′1½″	4′10″	4′ 0¾″	27	1½	2	1700
4 A	7300	4′1½″	4′10″	5′ 4½″	36	1½	2	1700
3 B	7300	5′1½″	4′10″	4′ 0¾″	33	1½	2	1700
2 C	7300	7′1½″	4′10″	2′ 9″	36	1½	2	1700
4 B	9800	5′1½″	4′10″	5′ 4½″	43	1½	2	1700
2 D	9800	9′1½″	4′10″	2′ 9″	47	1½	2	1700
3 C	11000	7′1½″	4′10″	4′ 0¾″	54	1½	3	1700
5 B	12300	5′1½″	4′10″	6′ 8″	54	1½	3	1700
4 C	14900	7′1½″	4′10″	5′ 4½″	72	1½	3	1700
3 D	14900	9′1½″	4′10″	4′ 0¾″	70	1½	3	1700
5 C	18700	7′1½″	4′10″	6′ 8″	90	2	3	1700
3 E	18700	11′1¾″	4′10″	4′ 1¼″	87	2	3	1700
4 D	20000	9′1½″	4′10″	5′ 4½″	94	2	3	1700
6 C	22500	7′1½″	4′10″	7′11¾″	108	2	5	1700
5 D	25200	9′1½″	4′10″	6′ 8″	117	2	5	1700
4 E	25200	11′1¾″	4′10″	5′ 5″	115	2	5	1700
6 D	30300	9′1½″	4′10″	7′11¾″	140	2½	5	1700
4 F	30300	13′1¾″	4′10″	5′ 5″	144	2½	5	1700
5 E	31600	11′1¾″	4′10″	6′ 8½″	144	2½	5	1700
7 D	35400	9′1½″	4′10″	9′ 3½″	164	2½	5	1700
6 E	38000	11′1¾″	4′10″	8′ 0¼″	173	2½	5	1700
5 F	38000	13′1¾″	4′10″	6′ 8½″	180	2½	5	1700
8 D	40500	9′1½″	4′10″	10′ 7¼″	187	2½	5	1700
7 E	44500	11′1¾″	4′10″	9′ 4″	202	2½	7½	1700
9 D	45700	9′1½″	4′10″	11′11″	210	2½	7½	1700
6 F	45800	13′1¾″	4′10″	8′ 0¼″	216	3	7½	1700
10 D	50500	9′1½″	4′10″	13′ 2½″	234	3	7½	1700
8 E	51000	11′1¾″	4′10″	10′ 7¾″	230	3	7½	1700
7 F	53500	13′1¾″	4′10″	9′ 4″	252	3	7½	1700
11 D	56000	9′1½″	4′10″	14′ 6¼″	258	3	7½	1700
9 E	57500	11′1¾″	4′10″	11′11½″	259	3	7½	1700
12 D	61000	9′1½″	4′10″	15′10″	281	3	7½	1700
8 F	61000	13′1¾″	4′10″	10′ 7¾″	288	3	7½	1700
7 G	62500	15′2″	4′10″	9′ 4½″	290	3	7½	1700
10 E	63500	11′1¾″	4′10″	13′ 3″	288	3	7½	1700
9 F	69000	13′1¾″	4′10″	10′ 8¼″	324	4	10	1120
11 E	70000	11′1¾″	4′10″	14′ 6¾″	317	4	10	1120
8 G	72000	15′2″	4′10″	11′11½″	332	4	10	1120
12 E	76500	11′1¾″	4′10″	15′10½″	346	4	10	1120
10 F	77000	13′1¾″	4′10″	13′ 3″	360	4	10	1120
9 G	81000	15′2″	4′10″	12′ 0″	373	4	10	1120
13 E	83000	11′1¾″	4′10″	17′ 2¼″	375	4	10	1120
11 F	85000	13′1¾″	4′10″	14′ 6¾″	396	4	10	1120
10 G	90000	15′2″	4′10″	13′ 3½″	414	4	10	1120
14 E	90000	11′1¾″	4′10″	18′ 6″	404	4	10	1120

Water supply ¾ inch, sewer connection 2 inches on all sizes. Additional sizes and capacities on request.

SECTION VII

STEAM ENGINES

In the following section will be found capacity and specification tables of Buffalo Steam Engines.

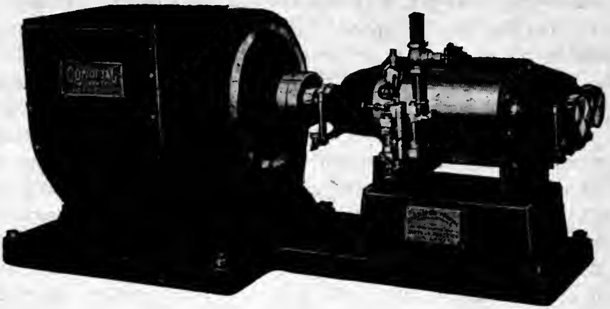
Two diagrams are given, showing the water rate of high speed engines and the ratio of the water rate at any cut-off as compared to the rated water rate, when the engines are rated at ⅜ cut-off. As an example of the use of these diagrams, we will take a case of a 100 H. P. high speed engine with steam pressure at 100 pounds and cutting off at ⅜ stroke. From the curve on page 486 we find the steam consumption will be 28 pounds per indicated H. P., or a total of 2800 pounds per hour. In case this was a heating job this would then be a measure of the amount of exhaust steam available for use in the heating coils. If, for any reason, this engine should be set to cut off at ⅝ stroke, we may determine the resulting steam consumption from the diagram on page 487. From the point marked ⅝ cut-off on the right edge of the chart, pass horizontally to the left until the cut-off line is intersected, thence downward to the curve, and horizontally to the left edge, where we find the water rate will be 104.2 per cent. of the rated. That is, $1.042 \times 28 = 29.2$ pounds per I. H. P. per hour.

The per cent. of rated load that will be developed may be determined from the scale at the bottom of the diagram. Drop vertically from the intersection of the ⅝ cut-off with the cut-off line to the bottom of the chart, where it will be found that the engine when cutting off at ⅝ stroke will develop 137.5 per cent. of the rated load, or $1.375 \times 100 = 137.5$ I. H. P.

The table of mean effective pressures has been calculated from actual indicator cards taken from automatic high speed engines. These values are applicable to engines of this class when exhausting at atmospheric pressure. In case back pressure is carried on the engine a corresponding correction should be made.

The horsepower tables for the various classes of engines give the brake horsepower per R. P. M., the maximum speed allowable and the corresponding horsepower developed. There are two factors limiting the speed of these engines; first, a maximum allowable piston speed; and second, the maximum load allowable, as indicated in the dimension table of each particular engine. In the case of the automatic engines the governors do not operate at a speed less than two-thirds of the maximum. There are a number of cases in the tables on pages 490 and 491 where, at certain steam pressures and cut-offs it was found necessary to limit the speed to less than two-thirds of the maximum in order to avoid overloading the corresponding engine frame. As indicated on the tables, these engines will have to be operated throttling, since the automatic governors will not be operative at these low speeds.

The two tables on pages 496 and 497 are applicable to Buffalo Class "A" automatic high speed engines. The maximum speed for each engine is shown, together with the minimum speed when operating with the automatic governor and also the brake horsepower that will be developed at the different steam pressures. Except as indicated these values are based on the engines operating at one-half cut-off. Those cases marked will have to cut off at less than one-half stroke in order to avoid overloading the engine.



Spiro Driven Niagara Conoidal (Type N) Fan for Forced Draft

Spiro Driven Gas Blower Unit

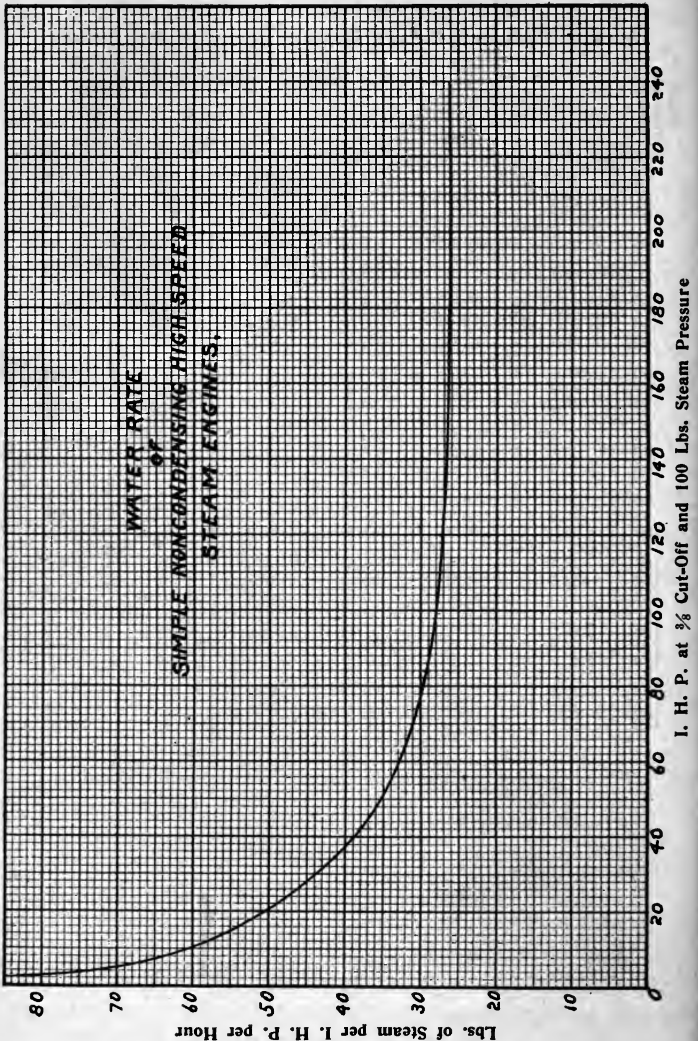
These illustrations show the adaptability of direct connecting various types of fans to Spiro Steam Turbines, which are made in sizes from 1 to 100 horsepower and operate very economically at a comparatively low speed.

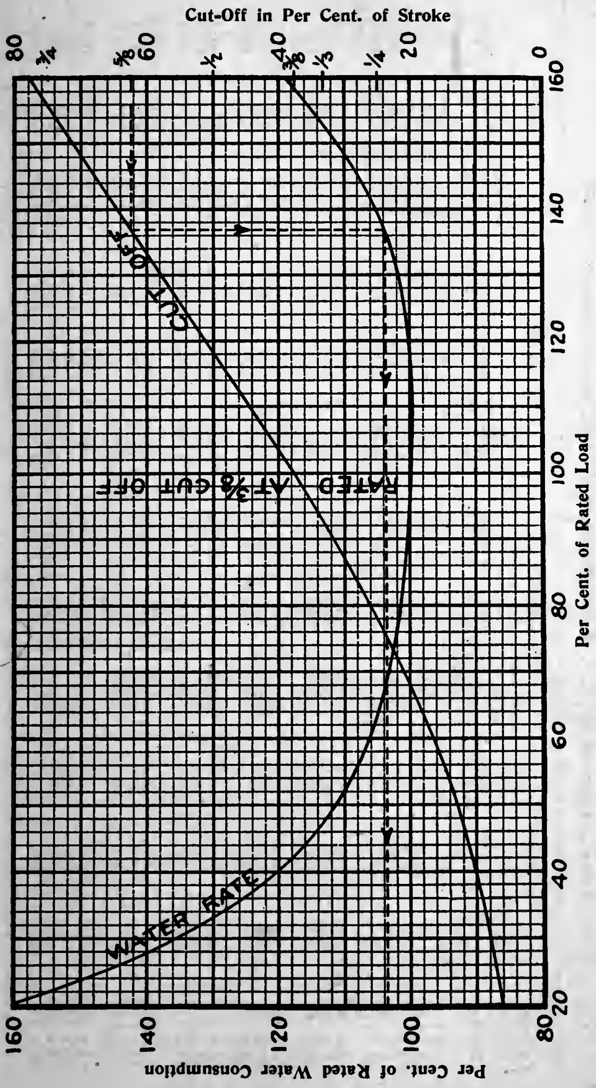
M. E. P. OF HIGH SPEED ENGINES*

Allowance Made for 10 Per Cent. Clearance and without Back Pressure

Steam Pressure Gauge	Cut-off					
	¼	⅛	⅜	½	⅝	¾
15	3.0	4.4	5.1	6.8	8.5	9.7
20	4.8	6.6	7.4	9.4	11.5	13.1
25	6.7	8.7	9.7	12.1	14.5	16.4
30	8.5	10.8	11.9	14.7	17.6	19.8
35	10.3	13.0	14.2	17.4	20.6	23.1
40	12.2	15.1	16.5	20.0	23.6	26.4
45	14.0	17.3	18.8	22.6	26.6	29.8
50	15.8	19.4	21.0	25.4	29.6	33.1
55	17.7	21.6	23.4	28.0	32.7	36.5
60	19.5	23.7	25.7	30.7	35.7	39.8
65	21.4	25.8	28.0	33.4	38.7	43.2
70	23.2	28.0	30.2	36.0	41.8	46.5
75	25.0	30.2	32.6	38.6	44.8	49.9
80	26.9	32.3	34.8	41.2	47.9	53.1
85	28.7	34.4	37.1	43.9	50.8	56.5
90	30.6	36.6	39.4	46.7	53.9	59.9
95	32.4	38.8	41.6	49.3	57.0	63.3
100	34.3	40.8	44.0	51.9	60.0	66.5
105	36.1	43.0	46.3	54.5	63.7	70.0
110	38.0	45.2	48.5	57.1	66.1	73.3
115	39.8	47.4	50.8	60.5	69.0	76.6
120	41.6	49.5	53.1	63.0	72.0	80.0
125	43.5	51.6	55.3	65.0	75.1	83.4
130	45.2	53.6	57.7	67.9	78.2	86.6
135	47.1	55.9	60.0	70.5	81.1	90.0
140	49.0	57.9	62.4	73.2	84.3	93.4
150	52.7	62.4	66.9	78.5	90.2	100.0

*NOTE—Based on indicator cards from an automatic high speed engine.


WATER RATE
of
SIMPLE NONCONDENSING HIGH SPEED
STEAM ENGINES.
I. H. P. at 3/8 Cut-Off and 100 Lbs. Steam Pressure
0
20
40
60
80
100
120
140
160
180
200
220
240
Lbs. of Steam per I. H. P. per Hour
10
20
30
40
50
60
70
80



Relative Water Rates of Simple, Non-Condensing High Speed Engines at Variable Loads

60 lbs.

BUFFALO HIGH SPEED ENGINES

CLASS "A" HORIZONTAL AND VERTICAL—STEAM PRESSURE, 60 LB. GAUGE

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	1/3 Cut-off			3/8 Cut-off			1/2 Cut-off			5/8 Cut-off		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
4 x 4	.0053	550	2.9	.0058	550	3.2	.0071	550	3.9	.0084	550	4.6
5 x 5	.0103	475	4.9	.0113	475	5.4	.0138	475	6.6	.0164	475	7.8
6 x 6	.0179	450	8.1	.0196	450	8.8	.0239	450	10.7	.0284	450	12.8
7 x 7	.0284	425	12.1	.0311	425	13.2	.0380	425	16.2	.0452	410	18.5
6 x 8	.0238	400	9.5	.0261	400	10.4	.0319	400	12.8	.0379	400	15.2
8 x 8	.0423	400	16.9	.0464	400	18.5	.0567	400	22.7	.0674	400	27.0
10 x 8	.0662	400	26.5	.0726	400	29.0	.0886	400	35.5	.1053	400	42.1
8 x 10	.0530	350	18.6	.0581	350	20.3	.0709	350	24.8	.0843	350	29.5
10 x 10	.0827	350	28.9	.0908	350	31.8	.1108	350	38.8	.1317	350	46.1
12 x 10	.1191	350	41.7	.1307	350	45.7	.1596	350	55.7	.1897	320	60.6
10 x 12	.0993	300	29.8	.1089	300	32.6	.1330	300	39.9	.1580	300	47.4
12 x 12	.1430	300	42.9	.1568	300	47.0	.1915	300	57.5	.2276	300	68.2
13 x 12	.1678	300	50.4	.1697	300	50.9	.2248	300	67.5	.2671	300	80.1
12 x 14	.1666	270	45.0	.1826	270	49.4	.2231	270	60.3	.2651	270	71.7
14 x 14	.2266	270	61.2	.2487	270	67.2	.3038	270	82.0	.3609	270	97.5
15 x 14	.2602	270	70.3	.2853	270	77.0	.3485	270	94.2	.4142	270	111.8
15 x 16	.2982	225	67.3	.3270	225	73.6	.3995	225	90.0	.4747	225	106.5
16 x 16	.3391	225	76.4	.3720	225	83.8	.4544	225	102.0	.5402	225	122.0
18 x 18	.4825	200	78.6	.5291	200	105.8	.6462	200	129.3	.7681	200	153.5
20 x 18	.5955	200	119.1	.6531	200	130.6	.7976	200	159.5	.9480	200	189.6

NOTE—Minimum speed to be not less than two-thirds the Maximum for Automatic Governors.

BUFFALO HIGH SPEED ENGINES

CLASS "A" HORIZONTAL AND VERTICAL—STEAM PRESSURE, 80 LB. GAUGE

80 lbs.

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	⅓ Cut-off			⅜ Cut-off			½ Cut-off			⅝ Cut-off		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
4 x 4	.0072	550	4.0	.0079	550	4.3	.0095	550	5.2	.0113	490	5.6
5 x 5	.0141	475	6.7	.0153	475	7.3	.0186	475	8.8	.0221	475	10.5
6 x 6	.0243	450	10.9	.0265	450	11.9	.0321	450	14.5	.0382	450	17.3
7 x 7	.0387	425	16.5	.0422	420	17.7	.0510	360	18.3	.0606	305	18.5
6 x 8	.0325	400	13.0	.0354	400	14.2	.0428	400	17.1	.0509	400	20.3
8 x 8	.0577	400	23.1	.0629	400	25.2	.0761	400	30.4	.0904	400	36.2
10 x 8	.0902	400	36.1	.0983	400	39.3	.1189	345	41.0	.1414	295	41.8
8 x 10	.0722	350	25.3	.0787	350	27.6	.0952	350	33.3	.1131	350	39.6
10 x 10	.1128	350	39.5	.1229	350	45.2	.1488	350	52.1	.1767	340	60.2
12 x 10	.1625	350	56.8	.1770	325	57.6	.2142	275	59.0	.2545	235	60.0
10 x 12	.1354	300	40.6	.1475	300	44.3	.1785	300	53.6	.2120	300	63.6
12 x 12	.1948	300	58.5	.2123	300	63.9	.2570	300	77.1	.3053	290	88.5
13 x 12	.2288	300	68.8	.2492	300	74.8	.3016	285	86.0	.3583	245	88.0
12 x 14	.2270	270	61.3	.2473	270	66.7	.2994	270	80.8	.3557	270	96.0
14 x 14	.3090	270	83.5	.3367	270	91.0	.4075	270	110.0	.4842	260	125.5
15 x 14	.3546	270	96.0	.3865	270	104.3	.4677	270	126.0	.5558	225	125.0
15 x 16	.4063	225	91.5	.4428	225	99.5	.5360	225	120.5	.6369	225	143.2
16 x 16	.4625	225	104.0	.5036	225	113.0	.6097	225	137.0	.7245	225	162.9
18 x 18	.6576	200	131.5	.7164	200	143.3	.8673	200	173.5	1.0305	200	206.0
20 x 18	.8117	200	162.3	.8842	200	176.8	1.0705	200	214.1	1.2720	200	254.4

NOTE—Minimum speed to be not less than two-thirds the Maximum for Automatic Governors.

100 lbs.

BUFFALO HIGH SPEED ENGINES
CLASS "A" HORIZONTAL AND VERTICAL—STEAM PRESSURE, 100 LB. GAUGE

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	⅓ Cut-off			⅜ Cut-off			½ Cut-off			⅝ Cut-off		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
4 x 4	.0091	550	5.0	.0105	510	5.4	.0120	455	5.5	.0142	395	5.6
5 x 5	.0178	475	8.4	.0194	475	9.2	.0234	465	10.9	.0276	405	11.2
6 x 6	.0308	450	13.9	.0336	450	15.1	.0405	450	18.2	.0478	390	18.6
7 x 7	.0489	360	17.6	.0533	335	17.8	.0643	285	18.3	.0760	240*	18.3
6 x 8	.0410	400	16.4	.0447	400	17.9	.0539	400	21.5	.0637	400	25.4
8 x 8	.0729	400	29.2	.0795	400	31.8	.0959	400	38.3	.1133	370	42.0
10 x 8	.1139	365	41.6	.1243	335	41.7	.1499	280	42.0	.1770	235*	41.6
8 x 10	.0912	350	31.9	.0994	350	34.8	.1199	350	42.0	.1417	350	41.6
10 x 10	.1425	350	50.0	.1554	350	54.4	.1874	315	59.0	.2213	275	60.8
12 x 10	.2051	280	57.4	.2238	260	58.0	.2760	215*	59.5	.3185	185*	59.0
10 x 12	.1709	300	51.2	.1864	300	56.0	.2248	300	67.5	.2656	300	79.6
12 x 12	.2461	300	74.0	.2684	300	80.6	.3237	265	85.9	.3825	230	88.2
13 x 12	.2888	290	83.8	.3150	270	85.0	.3799	225	85.8	.4489	195	88.0
12 x 14	.2867	270	77.5	.3127	270	84.5	.3771	270	101.8	.4456	270	120.5
14 x 14	.3903	270	105.5	.4257	270	115.0	.5134	240	123.0	.6055	205	124.0
15 x 14	.4480	270	121.0	.4886	270	131.8	.5892	270	159.0	.6962	265	185.0
15 x 16	.5133	225	115.2	.5600	225	126.0	.6752	225	152.0	.7978	225	179.0
16 x 16	.5839	225	131.0	.6368	225	143.0	.7680	225	173.0	.9074	225	202.0
18 x 18	.8305	200	166.0	.9060	200	181.0	1.0920	200	218.5	1.2910	200	258.3
20 x 18	1.0250	200	205.0	1.1182	200	223.7	1.3480	200	269.6	1.5935	200	318.7

NOTE—Minimum speed to be not less than two-thirds the Maximum for Automatic Governors. Those marked with a * are for Throttling Governors.

BUFFALO HIGH SPEED ENGINES

125 lbs.

CLASS "A" HORIZONTAL AND VERTICAL—STEAM PRESSURE, 125 LB. GAUGE

Brake Horsepower per R.P.M. and Maximum R.P.M. and Horsepower Allowable

Cylinder Diameter and Stroke	⅓ Cut-off			⅜ Cut-off			½ Cut-off			⅝ Cut-off		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
4 x 4	.0115	460	5.3	.0125	430	5.4	.0150	365	5.5	.0177	310*	5.5
5 x 5	.0225	470	10.6	.0244	440	10.7	.0293	370	10.8	.0346	325	11.2
6 x 6	.0389	450	17.5	.0422	420	17.7	.0507	360	18.2	.0598	310	18.6
7 x 7	.0618	285	17.6	.0700	260*	18.2	.0822	220*	18.1	.0953	190*	18.1
6 x 8	.0518	400	20.7	.0562	400	22.5	.0676	400	27.1	.0797	400	31.9
8 x 8	.0922	400	36.9	.0999	400	40.0	.1201	340	41.0	.1418	295	41.8
10 x 8	.1440	275	39.6	.1630	250*	40.8	.1920	210*	40.3	.2219	185*	41.0
8 x 10	.1153	350	40.4	.1250	350	43.8	.1502	350	52.6	.1773	340	60.5
10 x 10	.1801	315	57.0	.1953	295	57.6	.2347	250	58.8	.2770	210*	58.2
12 x 10	.2740	210*	57.5	.2940	195*	57.4	.3452	170*	58.6	.3985	145*	57.8
10 x 12	.2161	300	65.0	.2343	300	70.5	.2816	300	84.5	.3325	260	86.5
12 x 12	.3113	265	83.0	.3374	250	84.5	.4054	210	85.3	.4785	180*	86.0
13 x 12	.3653	235	83.6	.3959	215	85.0	.4860	175*	85.1	.5605	155*	86.9
12 x 14	.3625	270	98.0	.3930	270	106.0	.4723	260	123.0	.5576	220	123.0
14 x 14	.4936	250	123.0	.5350	225	120.0	.6565	185*	122.0	.7595	160*	121.0
15 x 14	.5665	270	153.0	.6141	270	165.8	.7380	245	181.0	.8714	215	187.0
15 x 16	.6492	225	146.0	.7036	225	158.0	.8457	225	190.3	.9986	225	224.5
16 x 16	.7384	225	166.0	.8004	225	180.5	.9620	225	216.0	1.1358	225	255.0
18 x 18	1.0505	200	210.0	1.1385	200	227.5	1.2205	200	244.0	1.6155	200	323.0
20 x 18	1.2965	200	259.3	1.4052	200	281.0	1.5064	200	301.3	1.9940	160	319.0

Note—Minimum speed to be not less than two-thirds the Maximum for Automatic Governors. Those marked with a * are for Throttling Governors.

BUFFALO LONG STROKE ENGINES CLASS "N" AND "S"

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	60 Lb. Pressure			80 Lb. Pressure			100 Lb. Pressure		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
5 x 10	.0329	300	9.9	.0442	300	13.3	.0553	300	16.6
6 x 10	.0474	300	14.2	.0636	300	19.1	.0797	300	23.9
7 x 12	.0775	250	19.4	.1088	250	27.2	.1301	250	32.5
8 x 12	.1012	250	25.3	.1357	250	33.9	.1700	250	42.5
8 x 14	.1178	225	26.5	.1581	225	35.6	.1981	225	44.6
9 x 14	.1492	225	33.6	.2001	225	45.0	.2506	225	56.4
10 x 20	.2631	100	26.3	.3530	100	35.3	.4422	100	44.2
12 x 20	.3788	90	34.1	.5084	90	45.8	.6368	90	57.3
15 x 20	.5922	80	47.4	.7943	80	63.5	.9950	80	79.7
16 x 24	.8091	65	52.6	1.0863	65	70.6	1.3600	65	88.4
18 x 24	1.0240	65	66.6	1.3739	65	89.3	1.7205	65	111.8
20 x 30	1.5805	65	102.7	2.1202	65	137.8	2.6560	65	172.6
22 x 30	1.9120	65	124.3	2.5658	65	166.8	3.2140	65	208.9
24 x 30	2.5757	65	148.0	3.0530	65	198.4	3.8240	65	248.6

BUFFALO HIGH SPEED ENGINES
DOUBLE VERTICAL—DOUBLE ACTING

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	⅛ Cut-off			⅜ Cut-off			½ Cut-off			⅝ Cut-off		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
80 Lb. Pressure												
3 x 3½	.0071	650	4.6	.0078	650	5.1	.0094	650	6.1	.0111	650	7.2
4 x 3½	.0126	650	8.2	.0138	650	9.0	.0167	650	10.9	.0198	650	12.9
4 x 4	.0144	600	8.7	.0157	600	9.4	.0190	600	11.4	.0226	600	13.6
5 x 4	.0226	600	13.6	.0246	600	14.8	.0298	600	17.9	.0354	525	18.6
6 x 5	.0405	500	20.2	.0442	500	22.1	.0534	500	26.7	.0635	500	31.7
7 x 5	.0552	500	27.6	.0601	500	30.0	.0728	435	31.6	.0865	375	32.5
8 x 8	.1154	400	46.2	.1257	400	50.3	.1523	360	55.0	.1809	310	56.0
100 Lb. Pressure												
3 x 3½	.0090	650	5.9	.0098	650	6.4	.0118	650	7.7	.0140	650	9.1
4 x 3½	.0160	650	10.4	.0174	650	11.3	.0210	650	13.7	.0248	650	16.1
4 x 4	.0183	600	11.0	.0199	600	12.0	.0240	600	14.4	.0284	600	17.0
5 x 4	.0285	600	17.1	.0311	580	17.7	.0375	485	18.2	.0443	420	18.6
6 x 5	.0512	500	25.6	.0558	500	27.9	.0673	475	31.9	.0795	410	32.6
7 x 5	.0697	440	30.6	.0760	410	31.2	.0917	345	31.6	.1083	300	32.5
8 x 8	.1458	360	52.5	.1590	335	53.5	.1918	285	54.6	.2265	245	55.6
125 Lb. Pressure												
3 x 3½	.0114	650	7.4	.0123	650	8.0	.0148	650	9.6	.0175	650	11.4
4 x 3½	.0202	650	13.1	.0219	650	14.2	.0263	650	17.1	.0311	600	18.6
4 x 4	.0231	600	13.9	.0250	600	15.0	.0301	600	18.1	.0355	525	18.6
5 x 4	.0361	490	17.7	.0391	455	17.8	.0470	390	18.3	.0555	335	18.6
6 x 5	.0647	475	30.6	.0702	445	31.2	.0843	380	32.0	.0996	325	32.4
7 x 5	.0881	350	30.6	.0955	325	31.0	.1148	275	31.5	.1356	240	32.6
8 x 8	.1844	285	52.5	.1999	265	53.0	.2402	225	54.1	.2836	195	55.3

NOTE—Minimum speed to be not less than two-thirds the Maximum for Automatic Governors.

BUFFALO HIGH SPEED ENGINES
SINGLE VERTICAL—CYLINDER BELOW SHAFT, CLASS "I"
Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	60 Lb. Pressure			80 Lb. Pressure		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
3 x 3½	.0042	600	2.5	.0056	600	3.6
4 x 3½	.0074	500	3.7	.0099	500	5.0
4½ x 5	.0133	400	5.3	.0178	400	7.1
5½ x 7	.0279	325	9.1	.0374	325	12.2
6½ x 8	.0445	275	12.2	.0597	275	16.4
7½ x 9	.0667	220	14.7	.0894	220	19.7

BUFFALO HIGH SPEED ENGINES
DOUBLE VERTICAL—SINGLE ACTING—CYLINDER ABOVE SHAFT
Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable

Cylinder Diameter and Stroke	60 Lb. Pressure			80 Lb. Pressure		
	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.	B. H. P. per R. P. M.	Max. R. P. M.	Max. B. H. P.
3 x 3	.0036	700	2.5	.0048	700	3.4
4 x 4	.0084	600	5.0	.0113	500	5.6
6 x 6	.0284	500	14.2	.0382	435	16.6
	100 Lb. Pressure			125 Lb. Pressure		
3 x 3	.0060	615	3.7	.0075	490	3.7
4 x 4	.0142	390	5.5	.0177	315	5.6
6 x 6	.0478	350	16.7	.0598	280	16.7

BUFFALO LOW PRESSURE ENGINES AT THREE-QUARTER CUT-OFF AND 3-LB. BACK PRESSURE

Brake Horsepower per R. P. M. and Maximum R. P. M. and Horsepower Allowable at Different Steam Pressures

Cylinder Diameter and Stroke	B. H. P. per R.P.M.	Max. R.P.M.	Max. B.H.P.	B. H. P. per R.P.M.	Max. R.P.M.	Max. B.H.P.	B. H. P. per R.P.M.	Max. R.P.M.	Max B.H.P.
	10 Lb. Pressure			15 Lb. Pressure			20 Lb. Pressure		
8x 6	0.00282	350	1.0	0.00794	350	2.8	0.01313	350	4.6
10x 8	0.00460	325	1.5	0.01522	325	4.9	0.02600	325	8.5
12x 8	0.0107	325	3.5	0.0261	325	8.5	0.0417	325	13.5
15x 8	0.0218	325	7.1	0.0457	325	14.8	0.0700	325	22.8
15x10	0.0210	300	6.3	0.0509	300	15.3	0.0813	300	24.4
16x10	0.0264	300	7.8	0.0604	300	18.1	0.0949	300	28.4
15x12				0.0514	250	12.8	0.0876	250	21.9
18x12	0.0362	250	9.1	0.0878	250	21.9	0.1404	250	35.1
18x14				0.0897	200	17.9	0.1510	200	30.2
18x16				0.0863	200	17.3	0.1560	200	31.2
	25 Lb. Pressure			30 Lb. Pressure			40 Lb. Pressure		
8x 6	0.01667	350	6.4	0.02835	350	9.9	0.03360	350	11.8
10x 8	0.03654	325	11.9	0.05758	325	18.8	0.06850	325	22.2
12x 8	0.0570	325	18.5	0.0720	325	23.4	0.1033	325	33.6
15x 8	0.0935	325	30.4	0.1174	325	38.2	0.1656	250	41.5
15x10	0.1109	300	33.2	0.1406	300	42.2	0.2010	300	60.3
16x10	0.1285	300	38.6	0.1624	300	48.8	0.2308	260	60.0
15x12	0.1233	250	30.8	0.1588	250	39.7	0.2310	250	57.8
18x12	0.1920	250	48.0	0.2423	250	60.7	0.3465	250	86.7
18x14	0.2108	200	42.2	0.2702	200	54.1	0.3920	200	78.5
18x16	0.2444	200	45.0	0.2925	200	58.5	0.4315	200	86.3

HORSEPOWER OF BUFFALO HIGH SPEED CLASS "A" ENGINES AT VARIOUS SPEEDS AND STEAM PRESSURES OF 60, 80, 100 AND 125 LB. GAUGE

Cylinder Diameter and Stroke	325 R. P. M.				350 R. P. M.				375 R. P. M.				400 R. P. M.			
	60	80	100	125	60	80	100	125	60	80	100	125	60	80	100	125
4 x 4									2.7	3.6	4.5	5.6	2.8	3.8	4.8	6.0*
5 x 5	4.5	6.0	7.6	9.5	4.8	6.5	8.2	10.2	5.2	7.0	8.8	11.0	5.5	7.5	9.4	12.0*
6 x 6	7.8	10.4	13.2	16.5	8.4	11.2	14.2	17.7	9.0	12.0	15.2	18.0*	9.6	12.8	16.2	18.0*
7 x 7	12.4	16.6	18.0*	18.0*	13.3	17.8	18.0*	18.0*	14.3	18.0*	18.0*	18.0*	15.2	18.0*	18.0*	18.0*
6 x 8	10.4	13.9	17.5	22.0	11.2	15.0	18.9	23.5	12.0	16.1	20.2	25.4	12.8	17.1	21.5	27.1
8 x 8	18.4	24.7	31.2	39.1	19.8	26.6	33.6	45.0*	21.2	28.8	36.0	45.0*	22.7	30.4	38.3	45.0*
10 x 8	28.6	38.6	45.0*	45.0*	31.0	41.6	45.0*	45.0*	33.2	45.0*	45.0*	45.0*	35.4	45.0*	45.0*	45.0*
8 x 10	23.0	30.9	39.0	48.8	24.8	33.3	42.0	52.6								
10 x 10	36.0	48.4	61.0	65.0*	38.8	52.1	65.0*	65.0*								
12 x 10	51.9	65.0*	65.0*	65.0*	55.9	65.0*	65.0*	65.0*								
													200 R. P. M.			
10 x 12													26.6	35.7	45.0	56.4
12 x 12													38.3	51.5	64.7	81.4
13 x 12													45.0	60.4	76.0	95.0*
									175 R. P. M.							
12 x 14									39.1	52.4	66.0	82.7	44.6	59.9	75.4	94.5
14 x 14									53.2	71.5	89.8	112.5	60.8	81.5	102.5	135.0*
15 x 14									61.0	81.9	103.0	129.0	69.8	93.5	117.8	147.5
					150 R. P. M.											
15 x 16					60.0	80.5	101.0	127.0	70.0	94.0	118.0	148.0	80.0	107.0	135.0	169.0
16 x 16					68.2	91.5	115.0	144.0	79.5	106.8	134.2	168.2	91.0	122.0	153.5	192.0
18 x 18					97.0	130.1	164.0	183.0	113.1	151.5	191.5	214.0	129.3	173.5	218.5	244.0
20 x 18					120.0	160.0	202.4	225.9	139.1	187.0	236.4	264.1	159.6	214.2	269.7	301.2

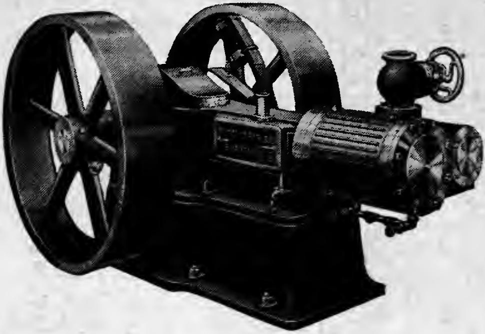
NOTE—H. P. marked * indicates engine cutting off at less than rated cut-off.

HORSEPOWER OF BUFFALO HIGH SPEED CLASS "A" ENGINES
AT VARIOUS SPEEDS AND STEAM PRESSURES OF 60, 80, 100 AND 125 LB. GAUGE

Cylinder Diameter and Stroke	425 R. P. M.				450 R. P. M.				475 R. P. M.				500 R. P. M.			
	60	80	100	125	60	80	100	125	60	80	100	125	60	80	100	125
4 x 4	3.0	4.0	5.1	6.0*	3.2	4.3	5.4	6.0*	3.4	4.5	6.0*	6.0*	3.6	4.7	6.0*	6.0*
													300 R. P. M.			
5 x 5	5.9	7.9	10.0		6.2	8.4	10.5		6.6	8.8	11.1					
									275 R. P. M.							
6 x 6	10.2	13.6	17.2	18.0*	10.7	14.5	18.0*	18.0*					7.2	9.6	12.1	15.2
					250 R. P. M.											
7 x 7	16,1	18.0*	18.0*	18.0*					10.5	14.0	17.7	18.0*	11.4	15.3	18.0*	18.0*
6 x 8					8.0	10.7	13.5	16.9	8.8	11.8	14.8	18.6	9.6	12.8	16.2	20.3
8 x 8					14.2	19.0	24.0	30.1	15.6	20.9	26.4	33.1	17.0	22.8	28.8	36.1
	225 R. P. M.															
10 x 8					22.2	29.7	37.5	45.0*	24.4	32.7	41.2	45.0*	26.8	35.7	45.0*	45.0*
8 x 10	15.9	21.4	27.0	33.8	17.7	23.8	30.0	37.6	19.5	26.2	33.0	41.3	21.3	28.5	36.0	45.1
10 x 10	24.9	33.5	42.2	52.8	27.7	37.2	46.9	58.8	30.5	41.0	51.5	65.0*	33.3	44.7	56.2	65.0*
12 x 10	35.9	48.3	65.0*	65.0*	39.9	53.6	65.0*	65.0*	43.9	59.0	65.0*	65.0*	47.9	65.0*	65.0*	65.0*
10 x 12	30.0	40.2	50.6	63.5	33.3	44.6	56.3	70.5	36.6	49.1	62.0	77.5	39.9	53.5	67.5	84.5
12 x 12	43.1	57.9	72.9	95.0*	47.9	64.2	81.0	95.0*	52.6	70.7	95.0*	95.0*	57.5	77.1	95.0*	95.0*
13 x 12	50.6	68.0	85.5	95.0*	56.3	75.5	95.0*	95.0*	62.0	83.0	95.0*	95.0*	67.5	95.0*	95.0*	95.0*
12 x 14	50.2	67.4	84.8	106.2	55.8	74.8	94.3	118.0	61.4	82.3	103.5	135.0*				
14 x 14	68.5	91.7	115.5	135.*	76.0	102.0	135.0*	135.0*	83.5	112.0	135.0*	135.0*				
15 x 14	78.5	105.0	132.5	166.0	87.2	117.0	147.0	184.5	96.0	128.5	162.0	200.0*				
15 x 16	90.0	120.6	152.0	190.3												
16 x 16	102.0	137.0	173.0	216.0												
18 x 18																
20 x 18																

NOTE—H. P. marked * indicates engine cutting off at less than rated cut-off.

BUFFALO HORIZONTAL ENGINES
CENTER CRANK, CLASS "A"

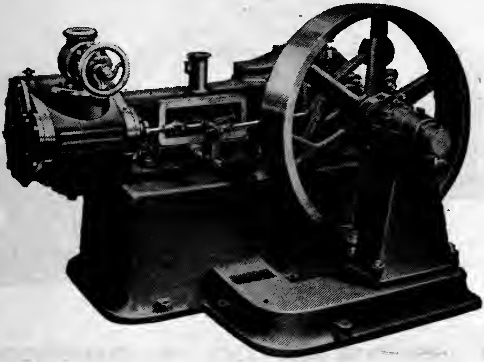


MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

High Pressure

Max. Horse-power	Max. R. P. M.	Cylinder Diameter and Stroke	Floor Space			Standard Fly-wheel		Steam and Exhaust Pipes		Shipping Weight Belted Engine 2 Wheels
			Length	Width	Height	Diam.	Face	Steam	Exh.	
45	400	6 x 8	73	40	42	39	7	2	2½	3300
45	400	8 x 8	73	40	42	39	7	2½	3	3380
45	400	10 x 8	73	40	42	39	7	3	3½	3560
65	350	8 x 10	80	56	60	49	11½	2½	3½	6320
65	350	10 x 10	80	56	60	49	11½	2½	3½	6490
65	350	12 x 10	80	56	60	49	11½	3½	4	6760
95	300	10 x 12	110	60	65	57	13	3½	4	9850
95	300	12 x 12	110	60	65	57	13	4	5	10000
95	300	13 x 12	110	60	65	57	13	4	5	10170
135	270	12 x 14	126	70	75	66	15	4	5	15950
135	270	14 x 14	126	70	75	66	15	5	6	16170
200	270	15 x 14	130	77	75	66	15	5	6	16390
285	225	15 x 16	144	88	80	72	16	6	7	22330
285	225	16 x 16	144	88	80	72	16	6	7	22440
350	200	18 x 18	161	95	88	84	18	7	8	30580
350	200	20 x 18	161	95	88	84	18	7	8	31790
Low Pressure										
45	325	12 x 8	73	40	42	39	7	3	3½	3780
45	325	15 x 8	73	40	42	39	7	3½	4	4000
65	300	15 x 10	80	56	60	49	11½	3	3½	7150
95	250	15 x 12	110	60	65	57	13	4	5	10830
95	250	18 x 12	110	60	65	57	13	5	6	11270
135	200	18 x 14	126	70	75	66	15	6	7	17270
200	200	18 x 16	130	77	75	66	15	6	7	22700

BUFFALO HORIZONTAL ENGINES
SIDE CRANK, CLASS "A"



MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

High Pressure

Max. Horsepower	Max. R.P.M.	Cylinder Diameter and Stroke	Floor Space			Standard Governor Wheel		Steam and Exhaust Pipes		Shipping Weight Belted Engine 1 Wheel
			Length	Width	Height	Diam.	Face	Steam.	Exh.	
20	450	6 x 6	66	42	44	33	6	2	2¼	2940
45	400	6 x 8	76	48	47	39	7	2	2½	3830
45	400	8 x 8	76	48	47	39	7	2½	3	3920
45	400	10 x 8	76	48	47	39	7	3	3½	4310
65	350	8 x 10	89	56	53	49	11½	2½	3	5390
65	350	10 x 10	89	56	53	49	11½	3	3½	5580
65	350	12 x 10	89	56	53	49	11½	3½	4	5850
95	300	10 x 12	110	64	62	57	13	3½	4	9300
95	300	12 x 12	110	64	62	57	13	4	5	9460
95	300	13 x 12	110	64	62	57	13	4	5	9570

Low Pressure

45	325	12 x 8	76	48	47	39	7	3	3½	4290
45	325	15 x 8	76	48	47	39	7	3½	4	4510
65	300	15 x 10	89	56	53	49	11½	3½	4	6240
65	300	16 x 10	89	56	53	49	11½	3½	4	6350
95	250	15 x 12	110	64	62	57	13	4	5	10175
95	250	18 x 12	110	64	62	57	13	5	6	10620

BUFFALO HORIZONTAL ENGINES

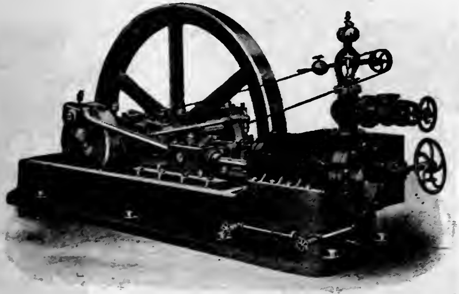
SIDE CRANK, CLASS "N"

MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

Max. H. P.	Max. R. P. M.	Cylinder Diameter and Stroke	Floor Space Inches			Standard Fly-wheel			Steam and Exhaust Pipes		Shipping Weight Complete
			Length	Width	Height	Diam.	Face	Weight	Steam	Exh.	
30	300	5 x 10	70	30	30	40	8½	450	1½	2½	1980
30	300	6 x 10	70	30	30	40	8½	450	1½	2½	2030
50	250	7 x 12	86	34	32	40	8½	450	2	3	2750
50	250	8 x 12	86	34	32	40	8½	450	2	3	2970
65	225	8 x 14	102	40	37	49	10	900	2½	3½	3850
65	225	9 x 14	102	40	37	49	10	900	2½	3½	4070

BUFFALO HORIZONTAL ENGINES

SIDE CRANK, CLASS "S"



MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

Max. H. P.	Max. R. P. M.	Cylinder Diameter and Stroke	Floor Space			Standard Fly-wheel			Steam and Exhaust Pipes		Shipping Weight Complete Reversing
			Length	Width	Height	Diam.	Face	Weight	Steam	Exh.	
90	100	10 x 20	162	50	61	72	5	2850	2½	3	8250
90	90	12 x 20	162	50	61	72	5	2850	2½	3	8800
90	80	15 x 20	168	52	68	96	8	4000	4	5	11000
125	65	16 x 24	178	60	72	96	9	6800	4	5	18370
125	65	18 x 24	178	60	72	96	9	6800	4	5	20000
275	65	20 x 30	192	64	76	108	10	10000	5	6	29700
275	65	22 x 30	192	66	80	108	10	10000	5	6	31300
275	65	24 x 30	192	66	80	108	10	12000	6	7	34300

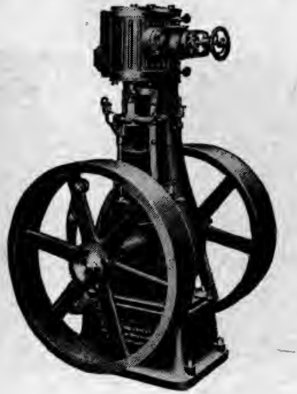
BUFFALO SINGLE VERTICAL ENGINES

CLASS "O"

MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

Max. Horse-power	Max. R.P.M.	Cylinder Diameter and Stroke	Floor Space			Standard Fly-wheel		Steam and Exhaust Pipes		Shipping Weight Belted Engine 2 Wheels
			Length	Width	Height	Diam.	Face	Steam	Exh.	
6	550	4 x 4	34	32	47	27	5½	1¼	1½	1320
12	475	5 x 5	37	35	55	31	6	1½	2	1800
18	450	6 x 6	41	42	65	33	6½	2	2½	2440
30	425	7 x 7	41	42	73	33	6½	2	2½	2800
45	400	8 x 8	43	44	76	39	7	2½	3	3840
65	350	10 x 10	52	56	96	49	11½	3	3½	6600
95	300	12 x 12	58	68	116	57	13	4	5	10000

BUFFALO SINGLE VERTICAL ENGINES
CLASS "A"

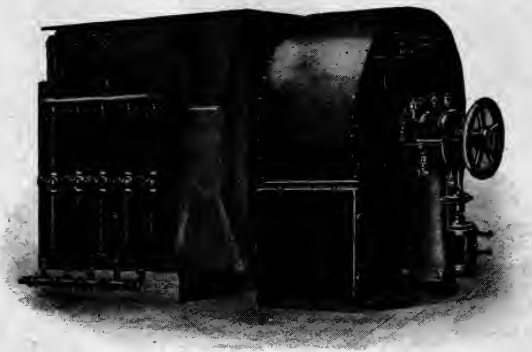


MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

High Pressure

Max. Horse-power	Max. R. P. M.	Cylinder Diameter and Stroke	Floor Space			Standard Fly-wheel		Steam and Exhaust Pipes		Shipping Weight Belted Engine 2 Wheels
			Length	Width	Height	Diam.	Face	Steam	Exh.	
6	550	4 x 4	34	32	46	27	5½	1¼	1½	1260
12	475	5 x 5	37	34	55	31	6	1½	2	1740
20	450	6 x 6	41	37	65	33	6½	2	2½	2400
20	425	7 x 7	41	37	65	33	6½	2	2½	2800
45	400	8 x 8	43	40	78	39	7	2½	3	3270
45	400	10 x 8	43	40	78	39	7	3	3½	3420
65	350	8 x 10	52	52	96	49	11½	2½	3	6070
65	350	10 x 10	52	52	96	49	11½	3	3½	6240
65	350	12 x 10	52	52	96	49	11½	3½	4	6460
95	300	10 x 12	62	64	118	57	13	3½	4	8830
95	300	12 x 12	62	64	118	57	13	4	5	9000
Low Pressure										
18	450	8 x 6	41	37	65	33	6½	2½	3	2450
45	400	12 x 8	43	40	78	39	7	3	3½	3780
45	400	13 x 8	43	40	78	39	7	3	3½	4160
45	400	15 x 8	43	40	78	39	7	3½	4	6490
65	350	15 x 10	52	52	96	49	11½	3	3½	7150
95	300	15 x 12	62	64	118	57	13	4	5	10830
95	300	18 x 12	62	64	118	57	13	5	6	11270

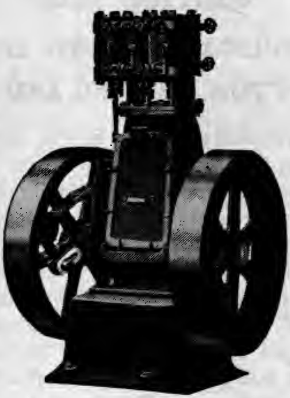
BUFFALO SINGLE VERTICAL ENGINES
CYLINDER BELOW SHAFT, CLASS "I"



MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

Max. Horsepower	Max. R. P. M.	Cylinder Diameter and Stroke	Steam and Exhaust Pipes		Weight of Engine with Hand Wheel
			Steam	Exhaust	
5	600	3 x 3½	1	1¼	340
7½	500	4 x 3½	1	1¼	370
11	400	4½ x 5	1¼	1½	780
18½	325	5½ x 7	1¼	1½	1100
25	275	6½ x 8	1½	2	1500
30	220	7½ x 9	2	2½	2000

BUFFALO DOUBLE VERTICAL ENGINES



MAXIMUM HORSEPOWER ALLOWABLE FOR CORRESPONDING FRAME

Single Acting

Max. H. P.	Max. R. P. M.	Cylinder Diameter and Stroke	Floor Space			Standard Fly-wheel			Steam and Exhaust Pipes		Shipping Weight Belted Engine 2 Wheels
			Length	Width	Height	Diam.	Face	Weight	Steam	Exh.	
4	700	3 x 3	32	30	28	24	4½	175	1	1¼	780
6	600	4 x 4	40	34	38	31	6	225	1¼	1½	1130
18	500	6 x 6	55	37	52	33	6½	425	2	2½	2700

Double Acting

20	650	3 x 3½	36	34	49	31	6	225	1½	2	1540
20	650	4 x 3½	36	34	49	31	6	225	1½	2	1600
20	600	4 x 4	36	34	49	31	6	225	2	2½	1680
20	600	5 x 4	36	34	49	31	6	225	2	2½	1760
35	500	6 x 5	52	42	70	39	7	520	3	3½	2960
35	500	7 x 5	52	42	70	39	7	520	3	3½	3080
60	400	8 x 8	68	52	88	49	11½	1000	3	3½	6100

SECTION VIII

PRACTICAL APPLICATIONS AND THE SELECTION OF APPARATUS FOR HEATING AND VENTILATING

As has been previously shown, one of the most important applications of fans is in connection with the heating and ventilation of industrial and public buildings. This work will be considered under two general divisions or classes: First, to supply heat; and second, to supply ventilation, where the heating may be done by direct radiation or by means of the fan as circumstances may determine. The first class embraces such buildings as shops and factories. The second class is more likely to be confined to such buildings as theatres, churches, hotels, etc. These buildings may be supplied with ventilation only, or with a combination of heating and ventilation, but the fan system is seldom used in such cases for heating alone.

The following examples will serve to illustrate these various systems, and the use of preceding rules, tables and data required in connection therewith will be explained. There are three factors entering into such calculations, the air required, the heat loss due to transmission and infiltration to be cared for, and the rise in temperature of the air above room temperature. In the various examples two of these conditions are given and the third is to be determined.

Class I. Heat the building, using either all return air, all outdoor air or a mixture of the two. In this case, the total heat loss is assumed to be known. For heating work where part or all of the air is returned from the room to the apparatus, it is customary to use a heater six sections deep with low pressure steam or five sections deep with high pressure steam. Where all outdoor air is used, either six or seven sections may be used with low pressure steam and five or six sections with high pressure steam. Knowing the temperature of the air entering the heater and assuming a suitable velocity of the air through the clear area, we may find from the heater tables on pages 418 to 431 the final or leaving temperature and so determine the temperature rise. Knowing the heat loss in B. t. u. per hour and the temperature rise, we may determine the air requirement from the formula

$$Q = \frac{55.2\ H}{60\ (t_2 - t_r)} \qquad \text{(for heating only)}$$

where Q = cu. ft. of air per min.

H = B. t. u. loss per hour due to transmission and infiltration.

t_2 = temperature of air leaving heater

t_r = room temperature.

In case all return air is used, the above H is a measure of the heat required to be delivered to the air by the heating coils. Where all or part of the air entering the heater is outdoor air at a temperature t_1, a greater amount of heat, H′, will be required, due to raising the temperature of this air from t_1 to room temperature t_r. This total heat, H′, is a measure of the condensation and steam requirement of the heating coils. It may be determined by the formula

$$H' = \frac{Q \times 60\ (t_2 - t_1)}{55.2} \qquad \text{(for heating)}$$

where H' = total heat required at the coils in B. t. u. per hour.

Q = cu. ft. of air per min.

t_1 = temperature of air entering heater.

t_2 = temperature of air leaving heater.

The three following examples illustrate in detail the various steps in the calculations of heating propositions:

Example 1. Supply heat only, using all return air.

Example 2. Supply heat, using all outdoor air. This condition frequently happens when the apparatus is so located that it is impracticable to run return ducts from the building to the heater.

Example 3. Heat the building, using part outdoor air and part return air.

Class II. Supply ventilation, either with or without heat. As already stated this is the usual requirement to be met in the case of public buildings. Here the known factors are the required amount of air for ventilation, the temperatures of the outdoor and of the room air, and the consequent temperature rise. The air to be delivered to the room at practically room temperature. The amount of heat and consequent size of heater is to be determined, the B. t. u. per hour to be supplied at the heater being indicated by the formula

$$H' = \frac{Q \times 60 (t_r - t_1)}{55.2} \qquad \text{(for ventilation only)}$$

where H' = B. t. u. per hour required at heater.
Q = cu. ft. air per min. for ventilation.
t_r = room temperature.
t_1 = outdoor, or temperature entering heater.

The amount of steam required by the heater may be determined by

$$\frac{H'}{\text{latent heat of steam}} = \text{lbs. condensation per hour.}$$

For ventilation work the final temperature of the air leaving the heater, t_2, is usually taken at the room temperature, t_r, when the room is heated by means of direct radiation, although it is customary to have the air leave the heater say from two to five degrees warmer to provide for radiation from the piping. In case both ventilation and heating are required, we have a different set of requirements. The known quantities then are the heat loss, H, to provide for the transmission and infiltration losses; the air quantity, Q, required for ventilation; and the temperature of the air entering the heater. The temperature of the air leaving the heater will have to be enough above the room temperature to care for the heat losses, and may be determined from the formula

$$t_2 = \frac{55.2\,H}{Q \times 60} + t_r \qquad \text{(for heating and ventilating)}$$

As already explained, the heat required at the heater will be

$$H' = \frac{Q \times 60\ (t_2 - t_1)}{55.2}$$

Knowing the temperature rise $(t_2 - t_1)$ and the air quantity, and assuming a suitable velocity of the air through the heater, the depth of the heater may be found from the heater tables on pages 418 to 431.

The three following examples illustrate the calculations necessary under this class of installations.

Example 4. Supply ventilation only, with a specified air change.

Example 5. Supply ventilation only, with a specified amount of air per minute supplied a given number of people.

Example 6. Supply a specified amount of air for ventilation and heat the building.

As an illustration we will assume a brick building 110×200 ft. in size, with a 13-inch brick wall and an average wall height of 20 ft. Building to be open to the roof, that is, no ceiling under the roof, which is to be of 2-inch boards, paper, tar and gravel. Loss from the floor to be neglected. Building to be warmed to 70° in zero weather.

From the tables of radiation coefficients we find that the factor for a 13-inch brick wall is 0.29, for glass surface is 1.1, and for a roof of this construction is 0.26. The total wall surface will be 12400 sq. ft. of which we will assume 3000 is glass surface and 9400 is brick wall. We will then have as the heat loss per hour per degree difference between the room and outdoor temperature,

Brick wall 9400 sq. ft. ×0.29	=2740
Glass 3000 sq. ft. ×1.1	=3300
Roof 23000 sq. ft. ×0.26	=5960
	12000 B. t. u.

or a total loss due to transmission of

$$H_t = 12000 \times 70 = 840000 \text{ B. t. u. per hour.}$$

The cubic contents of this building will be 440000 cu. ft.

Example 1. Supply heat only, using all return air.

As already shown, the heat loss from the building due to transmission will be 840000 B. t. u. per hour, to which we will add 10 per cent. giving the corrected loss as 924000 B. t. u. per hour.

In a system using return air at the heater, it is customary to allow for a certain amount of air leakage or infiltration, varying from once in one-half hour to once in two hours. This depends on several factors, such as the size and construction of the building, purposes for which it is used, etc. Assuming a loss due to infiltration of one change in two hours, we will have 220000 cu. ft. of air per hour to be warmed from 0° to 70°. The heat required to care for the infiltration loss will be

$$H_i = \frac{220000 \times 70}{55.2} = 379000 \text{ B. t. u. per hour}$$

The total heat required will then be

$$H = 924000 + 379000 = 1202000 \text{ B. t. u. per hour.}$$

As already stated, when using exhaust or low pressure steam it is considered good practice with return air to use a heater six sections deep. As the air is to be returned from the room, it will enter the heater at from 60° to 70°. From the table on page 421 we find that when using steam at five pound pressure with an entering temperature, t_r, of 60°, with six sections of heater we will have a leaving or final temperature, t_2, of 145° if the velocity through the heater is 1000 feet per minute.

If it is desired to figure closely, and the heater is so located that there will be no loss in temperature in returning the air—that is, the air enters the heater at room temperature, or $t_r = 70°$—the above value of $t_2 = 145°$ will not be correct. As the table does not give the final temperature when the entering temperature is 70° it will be necessary to refer to the curve on page 433. We find from this diagram that with an entering temperature of 70° and a velocity of 1000 feet per minute, the final temperature, t_2, will be 149°. The method of using this diagram is as follows: Selecting a temperature of 70° on the left-hand margin of the chart pass to the right to the intersection of the 1000 velocity curve, and dropping from here to the base line we have a reading of 4.35 sections. Selecting a new point of $6 + 4.35 = 10.35$ sections on this scale, pass upwards to the intersection of the vertical with the 1000 velocity curve and then to the left, where a final temperature of 149° is indicated.

The quantity of air at 70° required as a heat carrier will then be

$$Q = \frac{55.2 \times 1303000}{60\ (149 - 70)} = 15200 \text{ A. P. M.}$$

With a velocity of 1000 feet per minute through the heater we will require a clear area of $15200 \div 1000 = 15.2$ sq. ft. From the table on page 449 we find that a heater 4′6″ wide by 7′4″ high will have a clear area of 15.3 sq. ft. We will then require a heater containing six sections of this size.

As we would use a draw-through apparatus in a case like this, the fan will handle the air at 149° instead of at 70°, and the volume of the air will be correspondingly greater. This volume will vary inversely as the weight per cubic foot of the air, and the ratio of the volume at different temperatures as compared to the volume at 70° may be found from the table on page 13. Thus we find the same amount or weight of air at 150° will have

1.1512 times the volume at 70°. Then the fan must be selected on a basis of

$$15200 \times 1.1512 = 17500 \text{ cu. ft. per min.}$$

Assuming that in an installation of this nature, the total resistance against which the fan is to operate will be equal to one inch of water pressure, we will find from the tables of rated fan capacity the size of fan required to deliver 17500 A. P. M. against one inch total pressure. From the table on page 229 we find that a No. 8. Niagara Conoidal fan will deliver 17340 cu. ft. of air per minute against one inch total pressure when operating at 253 R. P. M. and will require 3.87 H. P.

This horsepower based on the values given in the capacity table is for air at 70° while the fan is to handle air at 149°. At constant capacity and speed the horsepower will vary approximately inversely as the absolute temperature, hence it will require less than the rated horsepower to handle this air which is at 149°. The actual brake horsepower required by the fan will then be

$$3.87 \times \frac{460+\ 70}{460+149} = 3.36 \text{ H. P.}$$

If the fan is to be motor driven, it will be necessary to select a motor of the next larger standard size, or 5 H. P. On account of the slow speed this fan should be belt driven.

Example 2. Heat the building, using all outside air at 0°.

As already explained under Example 1, when using return air it is customary to add 10 per cent. to the computed heat loss and also provide heat necessary to care for the infiltration loss. When using all outdoor air no provision is made for infiltration, but the calculated heat loss is generally increased by a greater margin—say 25 per cent. Sufficient heater must be provided to raise the temperature of the air from zero to room temperature, and enough higher to care for the heat loss from the building.

Adding 25 per cent. to the radiation loss gives 1050000 B. t. u. per hour required for heating. As shown by the heater table on page 420, with a velocity of 1000 feet per minute six sections of heater will raise the temperature of the air from 0° to 117°. Allowing a 2° drop due to the radiation loss from the piping gives a warm air temperature of 115° delivered to the room.

Then the quantity of air at 70° required will be

$$Q = \frac{55.2 \times 1050000}{60\ (115-70)} = 21450 \text{ A. P. M.}$$

This means approximately a 20 minute change. If possible the apparatus should be so arranged that return air may be used in the morning in order to heat up rapidly.

As the velocity through the heater is to be 1000 feet per minute, this calls for a clear area of 21.45 sq. ft. From the table on page 449 we find that a heater 6′0″×7′10″ will be the nearest standard size.

Example 3. Heat the building, using one-half outside air at 0° and one-half return air at 70°.

As already shown the heat loss from the building will be 840000 B. t. u. to which we will add 10 per cent., making the total loss 924000 B. t. u. per hour. This is the same as the loss figured for in Example 1, but since we are to use only one-half return air, we will allow but half the infiltration loss. This will require 190000 B. t. u. per hour. The total heat to be provided will then be

$$H = 924000 + 190000 = 1114000 \text{ B. t. u. per hour.}$$

Since half the air entering the heater is to be at 0° and half at 70°, we will assume an average of 35°. As none of the heater tables show the temperature rise for an entering temperature of 35°, we will make use of the diagram on page 433. Assuming a velocity through the heater of 1000 feet per minute, we pass from a temperature of 35° on the left edge of the chart to the intersection of the horizontal with the curve marked 1000 feet per minute. Dropping from here to the base line we have a reading of 2.65 sections. Assuming that we will use a heater six sections deep we will point off a new location on the base line at $2.65 + 6.0 = 8.65$ sections. Passing from here vertically to the intersection of the 1000 velocity curve and thence to the left edge of the diagram shows a temperature of 132° for the air leaving the heater. Allowing for 2° drop due to loss of heat from fan housing and piping gives an effective warm air temperature of 130°.

The quantity of air at 70° required will then be

$$Q = \frac{55.2 \times 1114000}{60\ (130-70)} = 17100 \text{ A. P. M.}$$

As we are to use a velocity of 1000 feet per minute through the clear area, a heater with a clear area of 17.10 sq. ft. will be required. From the table of heater dimensions on page 449, we find that a section of 5′0″×7′10″ will have a clear area of 17.7 sq. ft. We will then use a heater 5′0″×7′10″ six sections deep.

As shown above, the air required will be 17100 cu. ft. per minute at 70°, but if the fan is arranged to draw through the heater it will handle this air at 132°. The volume of the air will be greater than for the corresponding weight at 70°, the ratio as given in the table on page 13 being 1.114. This means that the fan will be required to handle

$$17100 \times 1.114 = 19100 \text{ A. P. M. at } 132°.$$

It is probable that the static resistance of an installation of this nature will not be over one inch, due to the resistance of 0.574 inch through the heater, the friction loss in the piping and any entrance or discharge losses that may exist. By referring to the static pressure tables of the Niagara Conoidal Fans on pages 247, 249 and 251, we find that we may use either a No. 7, 8 or 9 fan. Either of these fans may be used to give approximately the required capacity, but we see from the following summary that the outlet velocity, speed, and horsepower will be different in each case.

Size	Outlet Vel.	A. P. M.	R. P. M.	H. P.
7	2600	18580	336	5.93
8	2100	19600	289	5.61
9	1600	18900	264	5.71

If low first cost is the main consideration rather than power consumption, and if a comparatively high outlet velocity will not be objectionable, we should use the No. 7 fan. If the fan were to be used for a school or public building where any slight noise might be objectionable, the outlet velocity should be kept below 2100 to 2200. Under these circumstances the No. 8 should be used. If very low outlet velocity is of greater importance than first cost, the choice should fall upon the No. 9 fan. Where a fan is to be direct connected, the speed may also be a governing factor.

In any case, the horsepower as given on page 513 would be based on air at 70°, while the fan is to handle the air at 132°. That is, while the fan is to handle the 19100 cu. ft. per minute, due to the higher temperature, the density and therefore the horsepower required will be less than for the same volume at 70°. At constant capacity and speed, the horsepower will vary directly as the density of the air, and approximately inversely as the absolute temperature. We will then have the above horsepower decreased by the ratio

$$\frac{460+132}{460+\ 70}=1.114$$

That is, the above horsepower should be divided by 1.114.

Example 4. Supply ventilation only, with a ten minute air change.

In this case the heating of the building is to be taken care of by direct radiation, and the air required for ventilation will be taken from outside at 0° and introduced into the room at room temperature, or 70°. We are not concerned with the heat loss, but merely in raising an amount of air equal to the cubic contents of the room through a 70° temperature rise once in ten minutes or six changes per hour. Then we will have as the air at 70° required

$$\frac{440000}{10}=44000 \text{ cu. ft. per min.}$$

Assuming that this building is to be used for a factory, and inasmuch as the heater will be comparatively shallow with a corresponding low pressure drop, we may use a velocity of 1200 feet per minute through the heater. The total pressure against which the fan in such an installation is likely to operate will be about one inch. The temperature of the air leaving the heater should be about five degrees above room temperature to allow for radiation loss from the piping, etc.

From the heater table on page 420 we find that with five pound steam pressure and with 1200 velocity a temperature of 81.8° will be obtained with four sections of standard heater and will be the nearest temperature obtainable at this velocity.

Since we are to handle 44000 cu. ft. per minute at 1200 velocity we will require a heater having a clear area of

$$\frac{44000}{1200}=36.7 \text{ sq. ft.}$$

From the table of heater dimensions on page 449 we find that a section 9′6″×8′4″ has a clear area of 36.7 sq. ft. so this will be the size to use. We will then require a heater 9′6″×8′4″ and four sections deep.

In a large room of this construction it is customary to use a draw-through system, attaching the piping directly to the fan outlet. As already stated, the total pressure required for an installation of this character using but four sections of heater would probably run about one inch.

Referring to the table of fan capacities we may select a fan that will deliver 44000 A. P. M. against a pressure of one inch. From page 208 we find that a 160-inch Planoidal Exhauster will deliver 41220 A. P. M. against one inch at a speed of 164 R. P. M. and require 14.2 H. P. The 44000 A. P. M. required is 106.5 per cent. of the above rated capacity so it will be necessary to operate at a speed of 164×1.065 equals 175 R. P. M., and the power required will be $14.2 \times (1.065)^3$ equals 17.2 H. P.

This method of arriving at the speed and power required is only approximate, since when operating at other than the rated point the pressure will not be constant. For small increments of over or under load the speed may be changed slightly to bring the pressure to the desired amount, but for accurate work the method of using the diagram on page 215 as explained under Example 5 should be followed.

Example 5. Supply ventilation only, with 30 cu. ft. of air per minute for each of 500 occupants. This will require

$$30 \times 500 = 15000 \text{ A. P. M. at } 70°$$

which will be equivalent to $440000 \div 15000 = 29$ or approximately two changes per hour.

With a velocity of 1200 feet per minute through the heater, this will require a clear area of 12.5 sq. ft. From the table on page 449 we find that a section of 4′0″×6′10″ may be used. As the same temperature rise is required as in Example 4, the heater must be four sections deep and the final temperature 81.8°. If the heater and fan are located in the building so that there will be little or no radiation loss from the piping, the air may leave the heater at approximately 70°. We see from the heater table that with a velocity of 1000 feet per minute three sections will give a final temperature of 69.5°. By selecting a heater with a clear area slightly greater than indicated by 1000 velocity, we will obtain a final temperature somewhat above 70°. From the table of heaters we find that a 4′6″ x 7′4″ section will have a clear area of 15.3 sq. ft. and give a velocity of 980 feet per minute through the clear area. Thus we see that when using a final temperature of about 70° we may select three sections deep of 4′6″ x 7′4″ heater.

As we are using a low velocity and a heater only three sections deep, the loss in pressure through the heater will be only 0.287 inch, and it is probable that the static resistance of the entire system will not be over 0.6 inch. As under rated conditions the static pressure of a Planoidal Exhauster is 79 per cent. of the total pressure, if we use this type of fan operating at rated capacity the total pressure developed would be $0.6 \div 0.79 = 0.76$ inch or approximately ¾ inch.

From the table of fan capacities on page 207, we find that a 100-inch Planoidal Exhauster will deliver 13940 A. P. M. at 228 R. P. M. against ¾ inch total pressure and require 3.6 H. P. As 15000 A. P. M. is required, it will be necessary to operate this fan at greater than its rated capacity. We note from the diagram on page 214 that if this style of fan is operated at constant speed beyond its rated point the pressure will be less than the rated, so it will be necessary to operate at a speed corresponding to a certain higher pressure, in order to still have the required pressure when working over the rated capacity. The speed and horsepower to meet the required overload condition may be found approximately by means of the diagram on page 214, but as explained in the example on "Fan Selection" on page 183, the more accurate method is to use the diagram on page 215.

The outlet area of a 100-inch Planoidal Exhauster is 8.75 sq. ft., so at 15000 A. P. M. the outlet velocity will be 1715 feet per minute and the corresponding velocity pressure equals 0.183 inch. Since the static resistance of the system is 0.60 inch, the rated total pressure will be 0.60 + 0.183 = 0.783 inch. The ratio of static to velocity pressure = 0.6 ÷ 0.183 = 3.28. From the diagram on page 215 we find that with the above ratio we will be operating at 105 per cent. of the fans rated capacity, with 102.5 per cent. of the rated H. P., and the speed will be the rated speed for this fan when developing a total pressure of 0.783 inch.

This fan will give the following rated performance at the two different total pressures.

0.75 in. – 13940 A. P. M. – 228 R. P. M. – 3.6 H. P.
0.783 in. – 14250 A. P. M. – 233 R. P. M. – 3.85 H. P.

But 15000 ÷ 1.05 = 14300 A. P. M. as the rated capacity required, which is practically as given for 233 R. P. M. Then the power required under the overload condition will be

$$3.85 \times 1.025 = 3.95 \text{ H. P.}$$

From the above we see that the 100-inch fan will deliver 15000 A. P. M. against a static pressure of 0.6 inch at 233 R. P. M. and require 3.95 H. P.

Example 6. Heat the building and supply a 12½ minute air change for ventilation.

The outdoor air to be handled by the fan will be

$$\frac{440000}{12\frac{1}{2}} = 35200 \text{ A. P. M. at } 70^\circ$$

This air must be raised to room temperature for ventilation, and enough higher to supply the heat lost by radiation and leakage.

As already shown the heat lost by radiation from this building will be 840000 B. t. u. per hour. It is customary to allow an extra 10 to 50 per cent., depending on the construction of the building and the purposes for which it is used, to care for the heat lost by leakage, opening of doors, and similar causes. Allowing an extra 30 per cent. we will have as the total heat loss

$$H = 840000 + 252000 = 1092000 \text{ B. t. u. per hour.}$$

To determine the final temperature required we will have

$$t_2 = \frac{55.2 \times 1092000}{35200 \times 60} + 70 = 98.6^\circ$$

From the heater table on page 420 we find that with a velocity of 1000 feet per minute five sections of heater will raise the temperature of the air from 0° to 103°. As we are to handle 35200 A. P. M. at 1000 velocity, a heater having a clear area of 35.2 sq. ft. will be required. From the table on page 449 it may be seen that a heater section 8′6″ x 8′10″ has a clear area of 35.3 sq. ft. so this will be the size to use, the heater being five sections deep. In case this heater is too tall for the particular space it is to occupy, we may use two sections placed back to back, each having a clear area of 17.6 sq. ft. This would call for ten sections of 5′0″ x 7′10″ placed five sections deep.

COMBINATION FAN, ENGINE AND HEATER TABLES

The four tables on pages 520 to 523 indicate what are considered as being the proper combinations of heaters and engines for the different sizes of Planoidal and Niagara Conoidal fans. The cubic feet of air at one inch for public buildings and two inches for industrial installations may be considered as the probable maximum conditions to be encountered. The engine sizes given are for direct connection, and in most cases could be made to answer for these extreme conditions. Several sizes and styles of engines are given in order that a choice may be made to meet different requirements. For instance, where a 7 x 7 and an 8 x 8 inch cylinder are given for the same size fan, a higher steam pressure would be required for the smaller cylinder. A steam pressure of from 20 to 25 pounds will be required for the low pressure, and from 80 to 100 pounds for the high pressure engines.

The heater sizes given in the table indicate the proper heaters for use with the different sizes of fans. A heater should be selected with a clear area that will give the desired velocity of the air through the heater. This will range anywhere from 800 to 1200 feet per minute, depending on the conditions. Lower velocities should be used for public buildings than for industrial installations.

Fan, Heater and Engine Installation

PLANOIDAL (TYPE L) EXHAUSTERS

WITH PROPER COMBINATIONS OF HEATERS AND ENGINES FOR PUBLIC BUILDINGS AND INDUSTRIAL INSTALLATIONS

Size of Fan	Cubic Feet of Air per Min.		Buffalo Standard Heater				Engine Size	
	1 inch Total Press.	2 inch Total Press.	Arrangement	Style	Size	Clear Area Sq. Ft.	Low Press. Steam	High Press. Steam
50	4030	5690	Single	R.O.A.	3′–0″ x 3′– 4″	4.4		
55	4870	6890	Single	R.O.A.	3′–0″ x 3′–10″	5.2		3x3½ I
					3′–0″ x 4′– 4″	6.0		
60	5800	8200	Single	R.O.A.	3′–0″ x 4′– 4″	6.0	8x6	4x3½ I
					3′–0″ x 4′–10″	6.8		
					3′–0″ x 5′– 4″	7.6		
70	7890	11540	Single	R.O.A.	3′–0″ x 5′– 4″	7.6	8x6	4x3½ I
					3′–0″ x 5′–10″	8.4		
					4′–0″ x 5′– 4″	9.7		
80	10300	14570	Single	R.O.A.	4′–0″ x 5′–10″	10.7	8x6	5x5 4½x5 I
					4′–0″ x 6′– 4″	11.2		
					4′–0″ x 6′–10″	12.6		
					4′–6″ x 5′–10″	12.1		
					4′–6″ x 6′– 4″	13.1		
90	13040	18440	Single	R.O.A.	4′–6″ x 6′– 4″	13.1	8x6	5 x5 4½x5 I
					4′–6″ x 6′–10″	14.2		
					4′–6″ x 7′– 4″	15.3		
					5′–0″ x 6′– 4″	14.1		
					5′–0″ x 6′–10″	15.4		
					5′–0″ x 7′– 4″	16.6		
100	16100	22770	Single	R.O.A.	5′–0″ x 6′–10″	15.4	10x8	6 x6 4½x5 I 5 x10 N
					5′–0″ x 7′– 4″	16.6		
					5′–0″ x 7′–10″	17.7		
					6′–0″ x 7′– 4″	19.8		
110	19480	27540	Single	R.O.A.	6′–0″ x 7′– 4″	19.8	10x8	7 x7 6 x8 6½x8 I 5 x10 N
					6′–0″ x 7′–10″	21.3		
					6′–0″ x 8′– 4″	22.7		
					6′–0″ x 8′–10″	24.2		
				R.B.	7′–0″ x 7′– 4″	23.6		
120	23180	32780	Single	R.O.A.	6′–0″ x 8′– 4″	22.7	12x8	7 x7 8 x8 6½x8 I 6 x10 N
					6′–0″ x 8′–10″	24.2		
				R.B.	7′–0″ x 7′– 4″	23.6		
					7′–0″ x 7′–10″	25.4		
					7′–0″ x 8′– 4″	27.2		
					7′–0″ x 8′–10″	29.0		
130	27210	38470	Single	R.B.	7′–0″ x 8′– 4″	27.2	12x8	8 x8 6½x8 I 6 x10 N
					7′–0″ x 8′–10″	29.0		
					7′–0″ x 9′– 4″	30.7		
					7′–0″ x 9′–10″	32.5		
					8′–6″ x 8′– 4″	33.2		
140	31560	44630	Single	R.B.	7′–0″ x 9′– 4″	30.7	15x8	8 x8 8 x10 7½x9 I 7 x12 N
					7′–0″ x 9′–10″	32.5		
					8′–6″ x 8′– 4″	33.2		
					8′–6″ x 8′–10″	35.3		
					8′–6″ x 9′– 4″	37.6		
					8′–6″ x 9′–10″	39.8		
					8′–6″ x 10′– 4″	41.8		
					8′–6″ x 10′–10″	44.0		
					9′–6″ x 8′– 4″	36.7		
					9′- 6″ x 8′–10″	39.0		

PLANOIDAL (TYPE L) EXHAUSTERS

WITH PROPER COMBINATIONS OF HEATERS AND ENGINES FOR PUBLIC BUILDINGS AND INDUSTRIAL INSTALLATIONS

Size of Fan	Cubic Feet of Air per Min.		Buffalo Standard Heater				Engine Size	
	1 Inch Total Press.	2 Inch Total Press.	Arrangement	Style	Size	Clear Area Sq. Ft.	Low Press. Steam	High Press. Steam
150	36230	51220	Single	R.B.	8′-6″ x 8′-10″	35.3	15x8	10 x8 8 x10 7½x9 I 7 x12 N
					8′-6″ x 9′- 4″	37.6		
					8′-6″ x 9′-10″	39.8		
					8′-6″ x 10′- 4″	41.8		
					8′-6″ x 10′-10″	44.0		
					9′-6″ x 8′- 4″	36.7		
					9′-6″ x 8′-10″	39.0		
					9′-6″ x 9′- 4″	41.4		
					9′-6″ x 9′-10″	43.8		
					9′-6″ x 10′- 4″	46.0		
160	41220	58270	Single	R.B.	8′-6″ x 9′-10″	39.8	15x10	10x10 8x12 N
					8′-6″ x 10′- 4″	41.8		
					8′-6″ x 10′-10″	44.0		
					9′-6″ x 9′- 4″	41.4		
					9′-6″ x 9′-10″	43.8		
					9′-6″ x 10′- 4″	46.0		
					9′-6″ x 10′-10″	48.4		
					9′-6″ x 11′- 4″	50.8		
					9′-6″ x 11′-10″	53.2		
			Back to Back	R.O.A.	6′-0″ x 7′- 4″	39.6		
					6′-0″ x 7′-10″	41.6		
					6′-0″ x 8′- 4″	45.4		
					6′-0″ x 8′-10″	48.4		
				R.B.	7′-0″ x 7′- 4″	47.2		
					7′-0″ x 7′-10″	50.8		
170	46530	65790	Single	R.B.	9′-6″ x 10′- 4″	46.0	15x10	10x10 8x14 N 9x14 N
					9′-6″ x 10′-10″	48.4		
					9′-6″ x 11′- 4″	50.8		
					9′-6″ x 11′-10″	53.2		
			Back to Back	R.O.A.	6′-0″ x 8′- 4″	45.4		
					6′-0″ x 8′-10″	48.4		
				R.B.	7′-0″ x 7′- 4″	47.2		
					7′-0″ x 7′-10″	50.8		
					7′-0″ x 8′- 4″	54.4		
					7′-0″ x 8′-10″	58.0		
					7′-0″ x 9′- 4″	61.4		
180	52160	73760	Back to Back	R.B.	7′-0″ x 7′-10″	50.8	16x10	12x10 10x12 9x14 N
					7′-0″ x 8′- 4″	54.4		
					7′-0″ x 8′-10″	58.0		
					7′-0″ x 9′- 4″	61.4		
					7′-0″ x 9′-10″	65.0		
					8′-6″ x 8′- 4″	66.4		
190	58120	82180	Back to Back	R.B.	7′-0″ x 8′-10″	58.0	18x12	12x12 9x14 N
					7′-0″ x 9′- 4″	61.4		
					7′-0″ x 9′-10″	65.0		
					8′-6″ x 8′- 4″	66.4		
					8′-6″ x 8′-10″	70.6		
					8′-6″ x 9′- 4″	73.2		
					9′-6″ x 8′- 4″	73.4		

NIAGARA CONOIDAL (TYPE N) FANS

WITH PROPER COMBINATIONS OF HEATERS AND ENGINES FOR PUBLIC BUILDINGS AND INDUSTRIAL INSTALLATIONS

Fan No.	Cubic Feet of Air per Min.		Buffalo Standard Heater				Engine Size	
	1 Inch Total Press.	2 Inch Total Press.	Arrangement	Style	Size	Clear Area Sq. Ft.	Low Press. Steam	High Press. Steam
4	4340	6130	Single	R.O.A.	3′-0″ x 3′- 4″	4.4		
					3′-0″ x 3′-10″	5.2		
4½	5490	7760	Single	R.O.A.	3′-0″ x 3′-10″	5.2		4x4 A 3x3½ I
					3′-0″ x 4′- 4″	6.0		
					3′-0″ x 4′-10″	6.8		
5	6770	9580	Single	R.O.A.	3′-0″ x 4′- 4″	6.0	5x5	4x4 A 4x3½ I
					3′-0″ x 4′-10″	6.8		
					3′-0″ x 5′- 4″	7.6		
					3′-0″ x 5′-10″	8.4		
5½	8200	11590	Single	R.O.A.	3′-0″ x 5′- 4″	7.6	6x6	4x4 A 4x3½ I
					3′-0″ x 5′-10″	8.4		
					4′-0″ x 5′- 4″	9.7		
					4′-0″ x 5′-10″	10.7		
					4′-0″ x 6′- 4″	11.2		
6	9750	13790	Single	R.O.A.	4′-0″ x 5′- 4″	9.7	6x6	5 x5 A 4½x5 A
					4′-0″ x 5′-10″	10.7		
					4′-0″ x 6′- 4″	11.2		
					4′-0″ x 6′-10″	12.6		
					4′-6″ x 5′-10″	12.1		
					4′-6″ x 6′- 4″	13.1		
7	13280	18770	Single	R.O.A.	4′-0″ x 6′-10″	12.6	8x6	5 x5 A 5½x7 I
					4′-6″ x 5′-10″	12.1		
					4′-6″ x 6′- 4″	13.1		
					4′-6″ x 6′-10″	14.2		
					4′-6″ x 7′- 4″	15.3		
					5′-0″ x 6′- 4″	14.1		
					5′-0″ x 6′-10″	15.4		
					5′-0″ x 7′- 4″	16.6		
					5′-0″ x 7′-10″	17.7		
8	17340	24520	Single	R.O.A.	5′-0″ x 7′- 4″	16.6	10x8	6 x6 A 5½x7 I
					5′-0″ x 7′-10″	17.7		
					6′-0″ x 7′- 4″	19.8		
					6′-0″ x 7′-10″	21.3		
					6′-0″ x 8′- 4″	22.7		
9	21950	31020	Single	R.O.A.	6′-0″ x 7′- 4″	19.8	10x8	6 x6 A 6½x8 I
					6′-0″ x 7′-10″	21.3		
					6′-0″ x 8′- 4″	22.7		
					6′-0″ x 8′-10″	24.2		
				R.B.	7′-0″ x 7′- 4″	23.6		
					7′-0″ x 7′-10″	25.4		
					7′-0″ x 8′- 4″	27.2		
10	27090	38310	Single	R.B.	7′-0″ x 7′-10″	25.4	12x8	7 x7 A 6½x8 I 6 x10 N
					7′-0″ x 8′- 4″	27.2		
					7′-0″ x 8′-10″	29.0		
					7′-0″ x 9′- 4″	30.7		
					7′-0″ x 9′-10″	32.5		
					8′-6″ x 8′- 4″	33.2		
					8′-6″ x 8′-10″	35.3		

NIAGARA CONOIDAL (TYPE N) FANS

WITH PROPER COMBINATIONS OF HEATERS AND ENGINES FOR PUBLIC BUILDINGS AND INDUSTRIAL INSTALLATIONS

Fan No.	Cubic Feet of Air per Min.		Buffalo Standard Heater				Engine Size	
	1 inch Total Press.	2 inch Total Press.	Arrangement	Style	Size	Clear Area Sq. Ft.	Low Press. Steam	High Press. Steam
11	32780	46360	Single	R.B.	7′-0″ x 9′- 4″	30.7	12x8	8x 8 A 7½x 9 I 7 x12 N
					7′-0″ x 9′-10″	32.5		
					8′-6″ x 8′- 4″	33.2		
					8′-6″ x 8′-10″	35.3		
					8′-6″ x 9′- 4″	37.6		
					8′-6″ x 9′-10″	39.8		
					8′-6″ x 10′- 4″	41.8		
					8′-6″ x 10′-10″	44.0		
					9′-6″ x 8′- 4″	36.7		
					9′-6″ x 8′-10″	39.0		
					9′-6″ x 9′- 4″	41.4		
					9′-6″ x 9′-10″	43.8		
12	39010	55170	Single	R.B.	8′-6″ x 8′-10″	35.3	15x8	10x 8 A 8x10 A 7x12 N
					8′-6″ x 9′- 4″	37.6		
					8′-6″ x 9′-10″	39.8		
					8′-6″ x 10′- 4″	41.8		
					8′-6″ x 10′-10″	44.0		
					9′-6″ x 8′- 4″	36.7		
					9′-6″ x 8′-10″	39.0		
					9′-6″ x 9′- 4″	41.4		
					9′-6″ x 9′-10″	43.8		
					9′-6″ x 10′- 4″	46.0		
					9′-6″ x 10′-10″	48.4		
					9′-6″ x 11′- 4″	50.8		
13	45780	64730	Single	R.B.	8′-6″ x 10′- 4″	41.8	15x8	10x 8 A 8x12 N
					8′-6″ x 10′-10″	44.0		
					9′-6″ x 9′- 4″	41.4		
					9′-6″ x 9′-10″	43.8		
					9′-6″ x 10′- 4″	46.0		
					9′-6″ x 10′-10″	48.4		
					9′-6″ x 11′- 4″	50.8		
					9′-6″ x 11′-10″	53.2		
			Back to Back	R.O.A.	6′-0″ x 7′-10″	42.6		
					6′-0″ x 8′- 4″	45.4		
					6′-0″ x 8′-10″	48.4		
				R.B.	7′-0″ x 7′- 4″	47.2		
					7′-0″ x 7′-10″	50.8		
					7′-0″ x 8′- 4″	54.4		
					7′-0″ x 8′-10″	58.0		
14	53100	75090	Single	R.B.	9′-6″ x 10′-10″	48.4	15x10	10x10 A 8x14 N
					9′-6″ x 11′- 4″	50.8		
					9′-6″ x 11′-10″	53.2		
			Back to Back	R.O.A.	6′-0″ x 8′-10″	48.4		
				R.B.	7′-0″ x 7′-10″	50.8		
					7′-0″ x 8′- 4″	54.4		
					7′-0″ x 8′-10″	58.0		
					7′-0″ x 9′- 4″	61.4		
					7′-0″ x 9′-10″	65.0		
					8′-6″ x 8′- 4″	66.4		
					8′-6″ x 8′-10″	70.6		

PART V

APPENDIX

Complete directions for conducting Fan Installation Tests are included in this part.

This section also includes complete specifications and guarantees for various types of fans, heaters, piping, engines, motors, air washers and humidifiers; and detailed dimensions of Planoidal Steel Plate, Niagara Conoidal Multiblade and Turbo-Conoidal High Speed Multiblade Fans.

Data for the design of chimneys, with table giving size of chimneys with appropriate horsepower of boilers is included.

Miscellaneous engineering data is also given, including size of steam pipes, area of circles, temperature and pressure conversion tables, steam tables, logarithms, dry kiln capacities, many useful factors, etc.

An extract of the report of the committee of the Am. Soc. of H. & V. Engrs. on "Standards for Ventilation Legislation for Motion Picture Show Places" as presented in Jan., 1913, is reproduced.

A very complete and thorough index and cross-index, in addition to "Outline of Contents" in Part I, is given in this part.

Note—All temperatures given in this book are in degrees Fahrenheit unless otherwise specified.

DIRECTIONS FOR MAKING FAN INSTALLATION TESTS

The general subject of fan testing has been discussed on pages 190 to 204, with complete directions for using the pitot tube and for laying out a traverse of a pipe or duct. The detailed methods to be used in making a test on a fan installation, together with detailed instructions for working up the results of the test, will be given in the following:

Measuring the Air Quantity

1. Traverse over outlet or inlet pipe.
2. Traverse over fan outlet.

The velocity of the air and the quantity delivered should be determined by means of the pitot tube as explained on page 190. Whenever the nature of the installation makes it possible the most accurate results are obtained by making a traverse in the discharge or inlet duct. These velocity pressure readings should be taken at least 10 diameters, in the direction of the air flow, from the fan outlet, or from any bend, elbow, change in section, or other detail of construction that will cause a disturbance in the flow of air preceding the point at which the readings are taken. Readings at the fan inlet should be taken one diameter or more from the inlet.

While a traverse of the pipe is preferable, it is usually impracticable in actual installations to find a point where the air flow is undisturbed. In such cases a traverse with the pitot tube over the outlet area of the fan should be made.

The outlet area should be divided into 25 or more equal rectangles (5 or more each way) and velocity pressure readings taken in the center of each small area. The velocity corresponding to each of these velocity pressure readings should then be calculated as explained on page 18, and an average taken of these velocities. This gives the average velocity over the entire fan outlet, which in turn when multiplied by the area of the outlet in square feet gives the quantity of air delivered in cubic feet per minute. It will be noted that the **average velocity over the outlet should be obtained by taking an average of the various velocities and not of the various velocity pressure readings,** since the velocity varies as the square root of the pressure.

In taking the velocity pressure by means of a pitot tube, the connection between the two legs of the tube and the two sides of the gauge should be the same, whether the readings are taken in a duct either on the inlet or on the outlet side of the fan.

Measurement of Pressure Produced by the Fan

The relation between total, static and velocity pressure as produced by a fan has been explained on page 176. The measurement of the total or dynamic pressure is of especial importance since this is the pressure upon which the efficiency of the fan is based. This pressure is a measure of the total energy imparted to the air by the fan and is the difference between the average absolute total or dynamic pressure of the air on the two sides of the fan. The absolute pressure expressed in inches of water for air at 29.92 inches barometer will be the measured pressure plus 407 inches. The absolute total pressure at any point consists of the absolute static pressure plus the velocity pressure.

Since the total dynamic energy at any point in a stream of air is measured by the absolute total or dynamic pressure at that point, the gain or loss in energy between two points in a stream of air is measured by the difference between the absolute total pressures at these points. It follows that the total energy imparted by a fan to a given quantity of air is measured by the difference between the absolute total pressures measured at the inlet and outlet connections respectively and **that the total or dynamic pressure produced by a fan is equal to the difference between the absolute total or dynamic pressures at these two points.** Thus if an exhaust fan gives static and velocity pressure readings on the inlet side of 3″ and 0.5″ respectively, the absolute total pressure at the inlet will be (407 − 3) + 0.5 = 404.5″. If the static and velocity pressures on the outlet side are 2″ and 1″ respectively, the absolute total pressure at this point will be (407 + 2) + 1 = 410. Then the total pressure against which the fan is operating will be 410 − 404.5 = 5.5″. This may be expressed in gauge pressure as follows:

Total pressure of fan equals
The static pressure at fan outlet
+ the velocity pressure at fan outlet
+ the static vacuum (draft or suction) (or—static pressure) at the fan inlet
− the velocity pressure at fan inlet.

The static pressure produced by a fan equals the total pressure minus the velocity pressure at the fan outlet. It follows that

Static pressure of fan equals	The static pressure at the fan outlet +static vacuum at fan inlet (or − static pressure) −velocity pressure at fan inlet.
The Difference in static pressure at the inlet and outlet of the fan equals	The static pressure produced by the fan +the velocity pressure at the fan inlet.

It should be noted that the static vacuum at the fan inlet minus the velocity pressure at the fan inlet is the total pressure at this point.

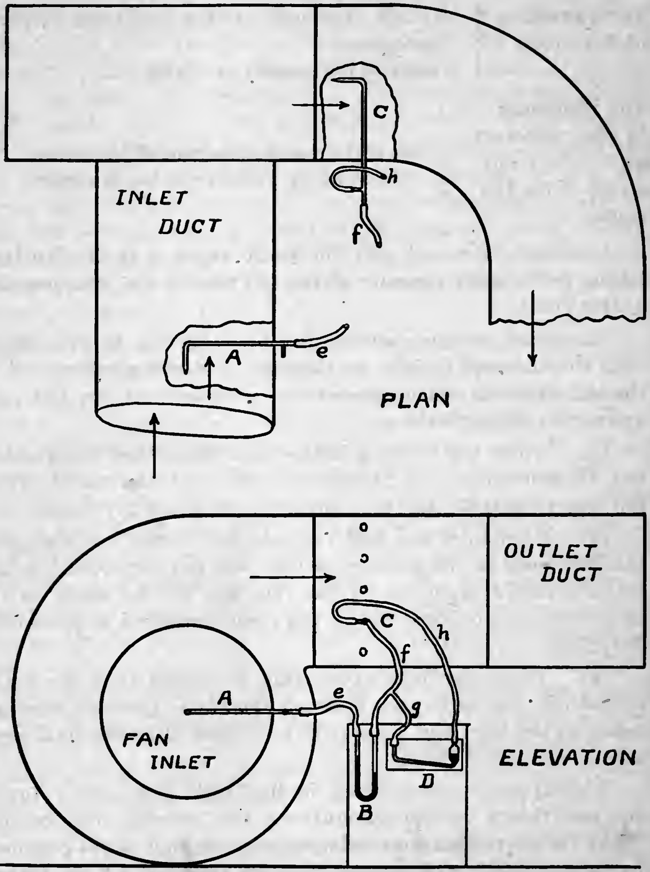
The static pressure as produced by the fan in accordance with the accepted definition does not necessarily correspond to the difference in static pressures as measured at the fan inlet and outlet respectively.

(a) Where the velocity in the inlet connection is negligible, the difference in static pressures at the inlet and outlet of the fan corresponds to the static pressure produced by the fan.

(b) If the inlet and outlet connections to the fan are equal, the difference in the static pressures will not correspond to the static pressure produced by the fan, but will be equal to the total pressure produced by the fan when measured as previously described.

(c) If the fan inlet connection is smaller than the outlet of the fan, the difference between the static pressure readings taken at the inlet and outlet will be greater than the total pressure produced by the fan.

This apparent discrepancy in the static pressures is due to the fact that a certain amount of static pressure may be produced by conversion from velocity pressure and is not produced by the fan itself. The static pressures specified for the various fans assume the fan to be exhausting from a large chamber having a negligible air velocity. It is evident that the pressures are greatly modified when exhausting through a duct.



Testing a Fan Installation

The proper arrangement of the gauges and the points at which the readings should be taken are shown on the drawing, page 528, which represents a fan drawing through one duct and blowing into another. A pitot tube is shown at A with the central or impact opening connected by a rubber hose to one side of a water column or draft gauge B. (For description of pitot tubes see page 190.) A second pitot tube is shown at C, having its impact or total pressure leg connected to the other side of the same gauge B. A cross connection is also made from this impact connection from pitot tube C to one leg of another gauge D and a connection made between the static leg of pitot tube C to the other side of this gauge. The readings obtained at D are then the difference between the total and static pressures, or the velocity pressure at the fan outlet. The gauge B gives the difference in total pressures at the two points A and C, or the total pressure developed by the fan. The static pressure will be the difference between the total and velocity pressure readings.

As already explained, a traverse should be made over the fan outlet, and the velocity pressure read at each point. The corresponding velocities should then be determined for each reading (see page 18) and an average taken of these various velocity readings. The velocity pressure corresponding to this final average velocity will be the average velocity pressure reading at the fan outlet, which on being added to the static pressure gives the total pressure on the fan.

Method of Calculating Fan Tests

The following are the various factors entering into the calculation of the performance of a fan as based on the results of a test. The object of such a test is to determine the pressure developed, the air quantity delivered, the power required and the efficiency of the fan. The various steps in the calculation may be stated as follows:

1. **The velocity pressure** is the pressure corresponding to the average velocity over the area of either the inlet or outlet of the fan.

2. **The total static pressure** produced by the fan is the arithmetical sum of the static readings on the two sides of the fan minus the velocity pressure at the fan inlet.

3. **The total or dynamic pressure** is the sum of the velocity and static pressures.

4. **The air quantity** is the product of the average velocity pressure times the area of the duct in which the readings were taken.

5. In case the fan is motor driven **the total power input** will be the product of the volts times the amperes as shown by the meters connected at the motor.

6. Careful readings of the speed of the fan and motor should be made at time of taking other readings.

7. **The I^2R loss** in watts for the current taken by the motor may be determined by means of a voltage drop test made with the wheel blocked. The I^2R loss is frequently assumed as being from 2 to 3 per cent. of the full load current of the motor.

8. **The belt and bearing loss** may be determined by removing the wheel from the shaft and taking power readings. Where this is impractical this loss may be assumed at from 3 to 5 per cent. of the power input, depending on the bearing conditions and on whether the fan is direct connected or belt driven. Some allowance should also be made for belt slip.

9. **No load power readings** should be obtained from the motor by disconnecting it from the fan or throwing off the belt. This no load current may frequently be determined from the characteristics of the motor.

10. **The actual power consumed by the fan** will then be the total watts input minus the no load watts and the various losses enumerated above, equals $(5) - [(7) + (8) + (9)]$.

11. **The brake horsepower** of the fan will be the net watts from item 10 divided by 746.

12. In case the fan is driven by means of a steam engine, indicator cards should be taken with the fan in operation and with the wheel removed or disconnected. The difference between the two sets of cards will give the brake horsepower consumed.

13. **The air horsepower** is the product of the air quantity handled in cubic feet per minute times the pressure in inches of water times a constant 0.000157 (see page 175).

14. **The total or dynamic efficiency** is the ratio of the product of the air quantity times the total or dynamic pressure in inches times 0.000157 divided by the brake horsepower.

$$\text{Total eff.} = \frac{\text{A. P. M.} \times \text{total press. in in.} \times 0.000157}{\text{Brake H. P.}}$$

15. **The static efficiency** is the ratio of the product of the air quantity times the static pressure in inches times 0.000157 divided by the brake horsepower and may be expressed as above by inserting static for total pressure in the formula.

It frequently occurs that a fan is guaranteed to give a certain performance under other than actual test conditions as to speed and temperature. In this case the test results should be corrected to the guaranteed speed and air density. As shown on page 179, the pressure developed will vary as the square and the power consumed as the cube of the speed. Both the pressure and power consumed will vary directly as the density of the air and should be multiplied by the ratio of the air densities under the two conditions. The density of the air may be determined from the table on page 17. These corrections should be made to the average pressure and the net power readings, before the air quantity and efficiency of the fan are calculated.

SPECIFICATIONS

STEEL PLATE FAN

Furnish and erect ( ) —— inch steel plate three-quarter (or full) housing, ——— discharge exhauster (or blower) having a capacity of — cubic feet of air per minute delivered against a static (or total) pressure of —— inches at a speed of ——— R. P. M., and requiring not over —— H. P.

Housing to be constructed of the best commercial steel plate No. — gauge, with riveted lap seams and braced by vertical and horizontal angle irons, — x —, and with angle iron base frame, — x —, drilled for holding-down bolts.

Fan to have one (or two) inlet — inches in diameter and an outlet — x — inches. If fan has a single inlet (exhauster) there shall be a cone extending inward to the inlet of the blast-wheel, so as to gradually increase the velocity of the air entering the wheel and so reduce the loss at entrance.

Blast-wheel to be — inches in diameter, constructed with a heavy cast iron hub into which T-iron arms are cast, firmly mounted by means of a key and set screw on a steel shaft — inches in diameter. The blades to be made of No. — gauge steel plate riveted to — x — T-iron spider arms cast into the hub, and to be tapering in shape, wider at the inlet than at the periphery. Side sheets of wheel to be flanged outward at the inlet and riveted to sides of blades.

Blast-wheel to be carefully balanced to prevent vibration.

Bearings to be spherical self-aligning ring-oiled type, lined with best quality babbitt, and so designed as to allow easy adjustment for wear. Bearings to be provided with large oil reservoir, and in case a bearing is mounted in the fan inlet it is to be provided with suitable arrangement for preventing oil from being drawn along shaft and into the fan by the entering air.

MULTIBLADE FAN

Furnish and erect ( ) No. —— multiblade three-quarter (or full) housing, ——— discharge single (or double) width fan having a capacity of —— cubic feet of air per minute delivered against a static (or total) pressure of —— inches with a velocity through the fan outlet of —— feet per minute, at a speed of —— R. P. M., and requiring not over —— H. P.

Housing to be constructed of the best commercial steel plate No. — gauge, with riveted lap seams and braced by vertical and horizontal angle irons, —— x ——, and with angle iron base frame, — x —, drilled for holding-down bolts.

Fan to have one (or two) inlet —— inches in diameter and an outlet —— x —— inches. If a double width fan is used, the wheel is to be composed of two separate single width wheels mounted back to back. Each inlet to be fitted with an inlet cone in the space between housing and wheel, having a minimum clearance with the flared inlet of the blast-wheel. In order to obtain the greatest possible conversion of velocity head at tip of blades into static pressure at fan outlet, the inner edge of the outlet is to be approximately tangent to periphery of wheel, and the height of the outlet approximately equal to wheel diameter.

Blast-wheel to be of the forward curved multiblade type, having thirty-two blades of No.— gauge steel plate riveted at the back to a boiler plate disk which in turn is to be hot-riveted to a conical cast iron hub. These blades to be connected by a flange at the inlet edge of the wheel. Hub is to be attached to the shaft by key and set-screws and to the inlet flange by four heavy tierods. The mean diameter of the blast-wheel to be — inches.

Blast-wheel to be carefully balanced to prevent vibration.

The heel or inner edge of the blades to be so arranged as to give a decreasing inlet diameter from front to back in order to give a uniform radial velocity through the wheel. The angle of the blades at entrance shall vary across the width in order to insure the entrance of air with the least possible loss by shock. The curvature of the blades to be such that at normal or rated capacity the air will leave the tips with a velocity pressure approximately twice the pressure corresponding to the peripheral velocity of the wheel, in order to reduce the required speed of rotation.

Bearings to be spherical self-aligning ring-oiled type, lined with best quality babbitt, and so designed as to allow easy adjustment for wear. Bearings to be provided with large oil reservoir, and in case a bearing is mounted in the fan inlet, it is to be provided with suitable arrangement for preventing oil from being drawn along shaft and into the fan by the entering air.

HIGH SPEED MULTIBLADE FAN

Furnish and erect ( ) three-quarter (or full) housing,——— discharge single (or double) width high speed multiblade fan having a capacity of ——cubic feet of air per minute delivered against a static (or total) pressure of —— inches at a speed suitable for direct connection to motor specified, and requiring not over —— H. P.

Housing to be constructed of the best commercial steel plate No. — gauge, with riveted lap seams and braced by vertical and horizontal angle irons, —— x ——, and with angle iron base frame, —— x ——, drilled for holding-down bolts.

Fan to have one (or two) inlet — inches in diameter and an outlet —— x —— inches. If a double width fan is used, the wheel is to be composed of two separate single width wheels mounted back to back. Each inlet to be fitted with an inlet cone in the space between housing and wheel, having a minimum clearance with the flared inlet of the blast-wheel. In order to obtain the greatest possible conversion from the high velocity pressure at tip of blades into a correspondingly high static pressure at the fan outlet, the inner edge of the outlet is to be approximately tangent to periphery of wheel, and the height of the outlet approximately equal to wheel diameter.

Blast-wheel to have thirty-two curved blades of No. — gauge steel plate riveted at the back to a boiler plate disk which in turn is to be hot-riveted to a conical cast iron hub. These blades to be connected by a flange at the inlet edge of the wheel. The hub to be attached to the shaft by key and set-screws and to the inlet flange by four heavy tierods. Blast-wheel to be carefully balanced to prevent vibration.

The heel or inner edge of the blades to be so arranged as to give a decreasing inlet diameter from front to back in order to give a uniform radial velocity through the wheel. The angle of the blades at entrance shall vary across the width in order to insure the entrance of the air with the least possible loss by shock at this point. The angle of the blades at the tip, or periphery of the wheel, to be such that a uniform delivery and pressure will be obtained across the width of the wheel.

Bearings to be spherical self-aligning ring-oiled type, lined with best quality babbitt, and so designed as to allow easy adjustment for wear. Bearings to be provided with large oil reservoir, and in case a bearing is mounted in the fan inlet, it is to be provided with suitable arrangement for preventing oil from being drawn along shaft and into the fan by the entering air.

FAN SYSTEM HEATER

Furnish and erect — four-row sections of pipe coil fan system heater, each section to be — ft. — in. long x —— ft. ——in. high. Each section to have heating surface equivalent to —— lineal feet of 1-inch pipe, and a clear area of —— sq. ft. for the passage of air.

The heater bases are to be of cast iron of uniform thickness, with heavy box section and extra heavy tops drilled and tapped for 1-inch pipe on 2⅝-inch centers, adjacent rows to be staggered so as to bring the air in intimate contact with the heating surfaces. For the purposes of accelerating the circulation, the base is to be provided with a partition separating the inlet from the return space. Steam and drip connections to be tapped as may be directed. Pipes to be threaded at each end with standard dies and screwed into base. Sections to be tested and made tight at 100 lbs. cold water pressure.

Heater casings to be of No. 18 gauge steel plate, stiffened at all edges and seams with 1½" x 1½" angle iron and extended to connect with the fan. The heater casing is to extend to the foundation so as to entirely enclose the cast iron bases, preventing radiation losses. Casing to cover both sides, top, and bottom of the heater.

A cast iron steam receiver is to be furnished with companion flanges tapped for individual connections to the several sections, and with a flanged opening for main steam supply.

FAN ENGINE

Furnish and erect ( ) ——— x——————————— horizontal (or vertical) center (or side) crank engine for belt drive (or direct connection). Engine to have cylinder —— inches in diameter by — inches stroke, and to operate at —— R. P. M. with initial steam pressure of — lbs. Steam pipe to be —— inches with exhaust pipe —— inches in diameter.

Engine to have a balanced piston valve so constructed as to take up wear in the surface of valve and valve seats. The eccentric rod is to connect to the valve stem crosshead by phosphor bronze bearing. Crankshaft to be a steel forging to which cast iron counter balance disks are solidly fitted.

Connecting rod to be of steel, with locomotive type end for crank pin, and solid end for carrying the crosshead pin boxes. The crosshead pin boxes are to be of phosphor bronze. Crank pin boxes are to be of cast iron lined with the best babbitt metal. Both ends of the connecting rod are to be provided with adjustment for taking up wear on the pin.

Crosshead guides are to be bored and have ample bearing surface.

Crossheads to be of cast steel, fitted with wedge-adjustable shoes for taking up wear and keeping the wrist pin in alignment with the cylinder.

All running surfaces are to be true to form and well polished.

The engine is to be filled and given a well finished painted surface before leaving the factory.

The following fittings to be furnished: Throttle valve, sight feed lubricator, necessary oil and grease cups, and full set of wrenches.

DUCT WORK

To be constructed and installed in accordance with Drawing No. —. Make all sheet metal ducts of best quality galvanized steel sheets, with slip joints in the direction of the air flow, rectangular ducts to have standing seams, and wide ducts to be stiffened by angle irons where necessary.

All round pipes of less than 5¼ to 8 sq. ft. of No. 24 gauge; 8 to 10½ sq. ft. of No. 22 gauge; 10½ to 13¼ sq. ft. of No. 20 gauge; 13¼ to 22½ sq. ft. of No. 18 gauge; above 22½ sq. ft. of No. 16 gauge.

All rectangular pipes less than 18 inches wide are to be made of No. 26 gauge; from 19 to 30 inches of No. 24 gauge; from 31 to 60 inches of No. 22 gauge; from 61 to 118 inches of No. 20 gauge; above 118 inches wide of No. 18 gauge.

No square turns are to be used at any point where it is possible to use curves, so as to offer the least possible resistance to the passage of air. All joints are to be smooth and tight, and all pipes are to be firmly hung and rigidly fastened in place. The work is to be left in first-class condition throughout.

Each branch rectangular duct is to be provided with a damper and quadrant which may be set and locked in position.

Round branch outlets to have adjustable butterfly dampers.

After erection test and set dampers for proper air distribution.

DIRECT CURRENT MOTOR

Furnish ( ) ——— H. P. ——— Volt direct current motor for direct (or belt) connection to fan at the speed specified. Motor to be of standard construction and equipped with starting rheostat, and furnished with

a—rheostat for starting duty only.

b—combined starting and speed regulating rheostat, capable of reducing the speed 50 per cent. below normal by armature resistance.

c—combined starting and speed regulating rheostat capable of increasing the speed — per cent. above normal by weakening the field circuit.

If direct connected to fan, motor is to be furnished without base rails or pulley, but with flanged coupling, key-seated, faced and polished.

If belted to fan, furnish pulleys of the proper size and single leather endless belt.

ALTERNATING CURRENT MOTOR

Furnish ( ) ——— H. P. ——— Volt —— cycle —— phase motor of standard construction with starter complete.

If direct connected to fan, motor is to be furnished without base rails or pulleys, but with flanged coupling, key-seated, faced and polished.

If belted to fan, furnish pulleys of the proper size and single leather endless belt.

SUBBASES

For fans direct connected to motors, furnish heavy steel plate subbase to be made tapering and with rounded corners and fitted with continuous angle iron extending around the base. Subbases must be braced inside and provided with hand hole for bolting down the motors. After erection the contractor is to fill the subbases with concrete to prevent transmission of sound.

CARRIER TYPE "A" AIR WASHER AND HUMIDIFIER

Furnish and erect where shown on plans one (1) air washer of a design as specified herein. Washer is to have a capacity of ——— cu. ft. A. P. M.

The velocity of the air through the washer shall not be greater than 500 ft. per minute and the total guaranteed resistance of the washer shall not exceed .25 inch water. Washer is to be 7′ 2⁵⁄₁₆″ long, —— wide and —— high.

Casing. The washer shall be constructed of galvanized iron of No. 18 gauge. Settling tank at least 16 inches high to extend under the entire washer and to be made of No. 16 gauge galvanized iron. The casing and tank shall be braced on the outside with 1½″ x 1½″ galvanized angles. These angles shall not be spaced further apart than 3 feet. All joints inside of casing shall be either soldered or made tight with rubber gaskets and bolts. All rivets and rivet holes shall be soldered over on inside of casing.

A perforated galvanized distributing plate on the inlet of the washer having 50 per cent. free area is to be provided.

Inspection Door. In the side of the washer casing is to be provided a door not less than 15″ x 24″ in size to allow easy and convenient access to the machine for inspection and cleaning. The door shall be of cast iron with two glass panels, each glass being not less than 9″ x 12″. The door frame is also to carry a ¼″ x ¼″ pure rubber gasket against which the door is to close. The frame is to be cast iron and riveted to the washer casing.

The door is to be held closed by at least three cams on each side; and be sufficiently rigid to prevent cracking of glass when clamping tight against gasket.

Sprays. The brass spray nozzles shall be evenly spaced over the cross section of the washer and shall be placed at least 4 feet from the eliminator plates and in a plane parallel thereto. The spacing of these nozzles shall be such that the entire interior of the washer between the nozzles and eliminator plates shall be uniformly filled with a finely divided spray. There shall be at least five nozzles for every 2000 cu. ft. of air handled per minute. The nozzles shall give a finely divided "mist like" spray. No water passage or way to be smaller than 27/1000 sq. in. area, nor have less than 3/16-inch minimum dimensions in any water passage. Stand-pipes shall be of 1 1/4-inch galvanized extra heavy wrought iron pipe screwed into a cast iron header. The flooding nozzles over the eliminators are to be spaced on 3-inch centers and handle 1 G. P. M. each.

Eliminators. The eliminators shall set vertical in position and be made of No. 24 gauge galvanized iron. The angles of the eliminators shall not be greater than 35°. The eliminators shall be so set that the air in passing through is deflected at least six times. Eliminator plates to be bolted or riveted directly to galvanized iron supports. The angles of deflection in no case being greater than 35°. No separate metal clips will be allowed. The space of air passage between any two adjacent eliminator plates shall not exceed 1 inch.

The washer shall be so arranged that the first four bends of the eliminator plates shall become a washing surface. A separate set of sprays (independent of the main sprays) is to be provided for maintaining a constant sheet of water flowing down these four surfaces continually. The amount of washing surface thus provided shall not be less than 40 sq. ft. per 1000 cu. ft. of air per minute.

The last two bends of the eliminator plates are to remove effectively all free and entrained moisture. The total washing and eliminating surface shall not be less than 60 sq. ft. per 1000 cu. ft. of air per minute.

Piping. 2-inch galvanized overflow and 2-inch drain to sewer, the latter provided with gate valve.

The washer is to be provided with galvanized iron flanges for piping connections.

Note. All piping between the washer, settling tank and pump shall be galvanized and be installed by contractor in accordance with details furnished by the air washer manufacturer.

Pump. The air washer is to be furnished with a —— double suction centrifugal horizontally divided shell pump having a capacity of —— gallons per minute when discharging against sufficient head to obtain perfect spray effect of all nozzles.

The pump is to be of the horizontal type having enclosed runner and is to be provided with cast iron base plate for direct connection to a —— H. P. motor of suitable current.

The casing of this pump is to be of grey cast iron, horizontally divided for convenient inspection, suitable to withstand an excess over the working pressure and designed with ample water ways for proper velocity.

All surfaces not machined shall be rubbed down, filled and painted a suitable dark color as directed.

The usual piping drains, fittings and grease cups are to be included.

Accessories. The washer is to be provided with an automatic float valve for maintaining a constant water level.

One strainer of 20-mesh copper screen is to be provided with the washer for straining all water recirculated by the pump. This strainer is to extend the entire width of the washer and shall have not less than 1 sq. ft. of surface for each 4000 cu. ft. of air handled per minute.

CARRIER TYPE "B" AIR WASHER AND HUMIDIFIER

Specifications for the Type "B" Air Washer and Humidifier are the same as for the Type "A" as given on pages 537 to 539 with the following exceptions:

Washer is 9′ 0⅜″ long instead of 7′ 2⁵⁄₁₆″ long.

There shall be at least five nozzles for every 1000 cu. ft. of air handled per minute instead of five nozzles for every 2000 cu. ft. of air handled per minute.

CARRIER TYPE "C" AIR WASHER AND HUMIDIFIER

To furnish and erect where shown on plans one (1) air washer of a design as specified herein. Washer is to have a capacity of ——— cu. ft. A. P. M.

The velocity of the air through the washer shall not be greater than 500 ft. per minute and the total guaranteed resistance of the washer shall not exceed .375 inch water. Washer is to be 4′ 10″ long, ——— wide and ——— high.

Casing. The washer shall be constructed of galvanized iron of No. 18 gauge. Settling tank at least 16 inches high to extend under the entire washer and to be made of No. 16 gauge galvanized iron. The casing and tank shall be braced on the outside with 1½″ x 1½″ galvanized angles. These angles shall not be spaced further apart than 3 feet. All joints inside of casing shall be either soldered or made tight with rubber gaskets and bolts. All rivets and rivet holes shall be soldered over on inside of casing.

Inspection Door. In the side of the washer casing is to be provided a door not less than 15″ x 24″ in size to allow easy and convenient access to the machine for inspection and cleaning. The door shall be of cast iron with two glass panels, each glass being not less than 9″ x 12″. The door frame is also to carry a ¼″ x ¼″ pure rubber gasket against which the door is to close. The frame is to be cast iron and riveted to the washer casing. The door is to be held closed by at least three cams on each side, and be sufficiently rigid to prevent cracking of glass when clamping tight against gasket.

Sprays. The brass spray nozzles shall be evenly spaced over the cross section of the washer and to be placed at least 4 feet from the eliminator plates and in a plane parallel thereto. The spacing of these nozzles shall be such that the entire interior of the washer between the nozzles and eliminator plates shall be uniformly filled with a finely divided spray. There shall be at least five nozzles for every 2000 cu. ft. of air handled per minute. The nozzles shall give a finely divided "mist like" spray. No water passage or way to be smaller than 27/1000 sq. in. area, nor have less than 3/16-inch minimum dimensions in any water passage. Stand pipes shall be of 1¼-inch galvanized extra heavy wrought iron pipe screwed into a cast iron header.

Eliminators. The eliminators are to be made of corrugated sheets of No. 24 galvanized iron. These eliminators are to be set vertically in rows so that the air has a tortuous passage through them and they are to be evenly spaced not further apart than 3¼″. They shall be braced and stiffened with galvanized angles.

At least two of the corrugations of the sheet are to be provided with a lip for catching any entrained moisture which otherwise may pass through eliminator.

Piping. The washer is to be provided with galvanized iron flanges for piping connections.

One (1) overflow connection and drain is also to be provided.

Note. All piping between the washer, settling tank and pump shall be galvanized and be installed by contractor in accordance with details furnished by the air washer manufacturer.

Pump. The air washer is to be furnished with a ——— double suction centrifugal horizontally divided shell pump having a capacity of ——— gallons per minute when discharging against sufficient head to obtain perfect spray effect of all nozzles.

The pump is to be of the horizontal type having enclosed runner and is to be provided with cast iron base plate for direct connection to a ——— H. P. motor of suitable current.

The casing of this pump is to be of grey cast iron, horizontally divided for convenient inspection, suitable to withstand an excess over the working pressure and designed with ample water ways for proper velocity.

All surfaces not machined shall be rubbed down, filled and painted a suitable dark color as directed.

The usual piping drains, fittings and grease cups are to be included.

Accessories. The washer is to be provided with an automatic float valve for maintaining a constant water level.

One strainer of 20-mesh copper screen is to be provided with the washer for straining all water recirculated by the pump. This strainer is to extend the entire width of the washer and shall have not less than 1 sq. ft. of surface for each 4000 cu. ft. of air handled per minute.

HUMIDITY CONTROL

The washer is to be provided with a system of humidity control arranged for maintaining a constant dew-point or saturated temperature of the air leaving the washer throughout the winter. This constant dew-point being maintained by varying the water temperature through which the air passes.

A thermostat is to be placed in the chamber between the washer and reheater coil. This thermostat shall be of a graduated action type to the approval of the engineer. In the suction line to the washer pump is to be provided an automatic combined ejector water heater and diaphragm valve to which a steam line is to be connected. In this steam line shall be placed a pressure reducing valve of the Mason Regulator Company's manufacture or equal by the steam contractor designed to maintain a pressure of 5 pounds per square inch on the ejector if high pressure steam is used. The operation of the automatic ejector water heater shall be gradual. This water heater is to be operated by a diaphragm operated by air pressure and a constant temperature thermostat placed between the eliminators and the reheating coil. A globe valve is to be provided in the steam line within a few feet of the water heater by the heating contractor.

Provide a reverse acting diaphragm steam valve which is to be placed in the steam line to the water heater and operated through a safety relay. The valve and relay are to be so connected that should either the water pressure or the air pressure fail, the steam supply to the ejector water heater will be automatically shut off.

One (1) ⅛-inch opening will be left in the air supply line of the thermostatic control system for supplying compressed air to the thermostat mentioned above. The humidity control shall be set and left in proper adjustment by the manufacturer.

One (1) Pot Strainer. For insertion in the line running from the centrifugal pump to spray header is to be provided a cast iron galvanized pot strainer with two baskets, one to be used as a spare. The baskets of this strainer are to be made of 14-mesh copper wire cloth screen, giving an area of at least sixteen times area of pipe connection. The top of this strainer is to be held by clamp and screw so it can be instantly and easily removed and replaced with clean strainer.

A ——— steam line is to be run to reverse acting diaphragm valve.

GUARANTEES

Apparatus

The apparatus is guaranteed to be first class with reference to both workmanship and design. Parts which may prove defective within one year after shipment are to be replaced without charge.

Fan

The fan shall be capable of handling — cu. ft. of air per minute at — degrees F. and 29.92 inches barometer, at approximately — inches static (or total) pressure, when running at a speed not to exceed —— R. P. M.

The fan will require under above conditions not over — H. P.

Heater

The free area through the coils shall be of such size that the velocity of the air in passing through them shall not exceed — feet per minute and of ample capacity to heat —— cu. ft. of air per minute from — to — degrees F. using steam at — pounds pressure per square inch gauge.

Engine

The engine shall be belted (or direct connected) to —— fan, and shall be capable of running at —— R. P. M. with steam pressure of —— pounds per square inch gauge, when fan is delivering —— cu. ft. A. P. M. against —— in. static (or total) pressure.

Heating

The apparatus is to be of sufficient capacity to heat the building to —— degrees F. when outside temperature is — degrees F., using —— per cent. return air— and —per cent. fresh air, and to give a — minute air change.

Ventilating

The apparatus is to be of sufficient capacity to supply— cu. ft. air per minute; (or in case of school, —— cu. ft. air per minute per pupil,) at —— degrees F. and 29.92 inches barometer.

Ducts and Outlets

The velocity shall not exceed: in the mains —— feet per minute; in the risers —— feet per minute.

The air shall enter the room —— at not less than —— feet from the floor, at a velocity not to exceed —— feet per minute.

The vent shall be of the size of the inlet and shall be taken off at the floor line where practicable.

Air Washing

The washer is to remove 98 per cent. of the solid material carried by the entering air.

Humidity Control

The apparatus is to automatically control the dew-point temperature within one degree of that desired, when the outside wet-bulb temperature is less than the dew-point for which the control is set.

Cooling With Air Washer

The apparatus when recirculating water in summer and handling rated capacity of air, is to reduce the temperature of the air 70 per cent. of the entering wet-bulb depression (i. e., 70 per cent. of the difference between the dry and wet-bulb temperatures) of the incoming air.

The apparatus when using cold water in summer is to reduce the outgoing difference of air and water temperatures to less than 25 per cent. of the difference in the incoming temperatures.

Cooling With Humidifier

Cool to the wet-bulb temperature of the entering air.

Mechanical Draft

The fan shall be used for (**induced or forced**) draft for—boilers burning —— pounds coal per hour, having a heat value of —— B. t. u. The fan shall be of sufficient capacity to handle —— cubic feet air per minute at —— degrees F. and 29.92 inches barometer and maintain a ——— pressure of —— inches of water at the grate, when revolving at a speed not to exceed — R. P. M.

The fan will require under above conditions not over —— H. P.

SPECIFICATIONS FOR PLANOIDAL (TYPE L) FANS

Size Fan	Outlet	Dia. of Inlet		Blast-Wheel			Dia. of Shaft			Gauges Fans under 1 oz. Press.				Gauges Induced Draft Fans and Fans over 1 oz. Press.				Base Angles	Side Angles
		Exhauster	Blower	Diameter	Width		Overhung Pulley	Overhung Wheel	Induced Draft	Side Sheets	Scroll Sheets	Blast-Wheel		Side Sheets	Scroll Sheets	Blast-Wheel			
					Exhauster	Blower						Blades	Flanges			Blades	Flanges		
30	10¾x10¾	13¼	11⅝	19¼	9¾	9¾	1 3/16	1 5/16		14	16	16	18	12	14	14	16	2 x2 x¼	
35	12½x12½	15⅜	13½	22½	11½	11½	1 3/16	1 5/16		14	16	16	18	12	14	14	16	2 x2 x¼	
40	14¼x14¼	17½	15½	25¾	13	13¼	1 7/16	1 7/16		14	16	16	18	12	14	14	16	2 x2 x¼	
45	16⅛x16⅛	19⅝	17⅜	28⅞	15	15⅛	1 7/16	1 11/16		14	16	16	18	12	14	14	16	2 x2 x¼	
50	17⅞x17⅞	23	19¼	32⅛	14⅞	16⅝	1 7/16	1 11/16		14	16	16	18	12	14	14	16	2 x2 x¼	2 x2 x¼
55	19⅝x19⅝	25½	21¼	35⅜	16½	18⅜	1 7/16	1 13/16		14	16	16	18	12	14	14	16	2 x2½x¼	2 x2 x¼
60	21½x21½	28½	23⅛	38½	17⅞	20¼	1 11/16	1 13/16		14	16	16	18	12	14	14	16	2 x2½x¼	2 x2 x¼
70	25 x25	35	27	45	21	23¾	1 11/16	1 15/16		14	16	16	18	12	14	14	16	2 x2½x¼	2¼x2¼x¼
80	28½x28½	40	30⅞	51⅜	23⅞	27¼	1 15/16	1 15/16		14	14	16	18	12	12	14	16	2 x3 x¼	2¼x2¼x¼
90	32¼x32¼	45	34¾	57⅞	27¼	30¾	1 15/16	2 3/16		14	14	16	18	12	12	14	16	2 x3 x¼	2½x2½x¼
100	35¾x35¾	50	38⅝	64¼	30⅛	34¼	2 3/16	2 7/16	2 7/16	14	14	14	16	12	12	12	14	2 x3 x¼	2½x2½x¼
110	39¼x39¼	55	42½	70¾	33	37¾	2 3/16	2 11/16	2 11/16	14	14	14	16	12	12	12	14	2½x3½x¼	2½x2½x¼
120	43 x43	60	46¼	77¼	36¼	41½	2 7/16	2 15/16	2 15/16	14	14	14	16	12	12	12	14	2½x3½x¼	3 x3 x⅜
130	46½x46½	65	50⅛	83½	39¼	45	2 11/16	3 3/16	3 3/16	14	14	14	16	12	12	12	14	3 x4 x⅜	3 x3 x⅜
140	50 x50	70	54	90	42	48½	2 15/16	3 7/16	3 7/16	14	12	14	16	12	10	12	14	3 x4 x⅜	3½x3 x⅜
150	53½x53½	75	57⅞	96½	45¼	51¾	3 3/16		3 15/16	14	12	14	16	12	10	12	14	3 x4 x⅜	4 x4 x⅜
160	57 x57	80	61¾	103	48¼	55¼	3 7/16		4 7/16	12	12	14	16	10	10	12	14	3½x5 x⅜	4 x4 x⅜
170	60¾x60¾	85	65⅝	109¼	51	59	3 11/16		4 15/16	12	12	12	14	10	10	10	12	4 x5 x⅜	4 x4 x⅜
180	64¼x64¼	90	69½	115¾	54½	62¼	3 15/16		5 3/16	12	12	12	14	10	10	10	12	4 x5 x⅜	4 x4 x⅜
190	67¾x67¾	95	73¼	122¼	57¼	65¾	4 3/16		5 7/16	12	12	12	14	10	10	10	12	4 x5 x⅜	4 x5 x⅜
200	71½x71½	100	77¼	128½	60¼	69½	4 7/16		5 15/16	12	12	12	14	10	10	10	12	4 x5 x⅜	4 x5 x⅜

SPECIFICATIONS FOR NIAGARA CONOIDAL (TYPE N) FANS

Size Fan	Outlet		Diameter of Inlet	Wheel						Diameter Shaft			
				Diameter		Width				Single Fan		Double Fan	
						Single Fan		Double Fan					
	Single Fan	Double Fan		Maximum	Mean	At Center	At Tip	At Center	At Tip	Overhung Pulley	Overhung Wheel	In Wheel	In Bearings
3	12 x 15¾	24 x 15¾	17¼	16¾	15⅝	6½	5⅜	13	10¾	1 3/16	1 5/16	1 7/16	1 7/16
3½	14 x 18⅜	28 x 18⅜	20	19½	18¼	7½	6¼	15	12½	1 3/16	1 7/16	1 11/16	1 11/16
4	16 x 21	32 x 21	22¾	22¼	20 13/16	8⅝	7⅛	17¼	14¼	1 3/16	1 11/16	1 11/16	1 11/16
4½	18 x 23⅝	36 x 23⅝	25¾	25⅛	23 7/16	9¾	8	19½	16	1 3/16	1 13/16	1 15/16	1 15/16
5	20 x 26¼	40 x 26¼	28½	27⅞	26	10⅞	9	21¾	18	1 7/16	1 15/16	1 15/16	1 15/16
5½	22 x 28⅞	44 x 28⅞	31½	30¾	28⅝	11 15/16	9⅞	23⅞	19¾	1 7/16	2 1/16	2 3/16	2 3/16
6	24 x 31½	48 x 31½	34¼	33½	31¼	13	10¾	26	21½	1 11/16	2 3/16	2 7/16	2 3/16
7	28 x 36¾	56 x 36¾	39¾	39	36½	15⅛	12½	30¼	25	1 15/16	2 3/16	2 11/16	2 3/16
8	32 x 42	64 x 42	45½	44⅝	41⅝	17⅜	14⅜	34¾	28¾	2 3/16	2 7/16	3 3/16	2 7/16
9	36 x 47¼	72 x 47¼	51¼	50¼	46⅞	19½	16¼	39	32½	2 11/16	2 15/16	3 11/16	2 11/16
10	40 x 52½	80 x 52½	56¾	55¾	52⅛	21¾	18	43½	36	2 11/16	3 3/16	3 15/16	2 15/16
11	44 x 57¾	88 x 57¾	62½	61½	57⅜	24	19¾	48	39½	3 3/16	3 11/16	4 15/16	3 7/16
12	48 x 63	96 x 63	68	67	62½	26	21½	52	43	3 7/16	3 15/16	5 7/16	3 15/16
13	52 x 68¼	104 x 68¼	73½	72½	67¾	28	23¼	56	46½	3 11/16	4 3/16	5 11/16	4 3/16
14	56 x 73½	112 x 73½	79	78	72⅞	30½	25¼	61	50½	3 15/16		6¼	4 7/16
15	60 x 78¾	120 x 78¾	84¾	83¾	78⅛	32½	26⅞	65	53¾	4 3/16		6¾	4 15/16
16	64 x 84	128 x 84	90¼	89⅜	83⅜	34¾	28¾	69½	57½	4 11/16		7¼	5 7/16
17	68 x 89¼	136 x 89¼	96	95	88⅝	36⅞	30½	73¾	61	4 15/16		8	5 11/16
18	72 x 94½	144 x 94½	101½	100½	93¾	39	32¼	78	64½	5 7/16		8½	6 3/16
19	76 x 99¾	152 x 99¾	107	106	99	41 5/16	34 3/16	82⅝	68⅜	5 11/16		9	6 7/16
20	80x105	160x105	112¾	111¾	104¼					6 3/16		9¾	6 15/16

All Niagara and Turbo-Conoidal Fans have 32 Blades. Turbo-Conoidal (Type T) Fans have same dimensions as in table above, except blast-wheel and shaft, which may vary, depending on operating conditions.

SPECIFICATIONS FOR NIAGARA CONOIDAL (TYPE N) FANS

Size Fan	Gauges Fans under 1-oz. Pressure						Gauges Induced Draft Fans and Fans over 1-oz. Pressure						Base Angles	Side Braces
	Side Sheets		Scroll Sheets	Blast-Wheel			Side Sheets		Scroll Sheets	Blast-Wheel				
	Full Housing	Three-quarter Housing		Blades	Disk	Flange	Full Housing	Three-quarter Housing		Blades	Disk	Flange		
3	14	14	16	18	10	14	12	12	14	16	8	12	2 x2 x¼	
3½	14	14	16	18	10	14	12	12	14	16	8	12	2 x2 x¼	
4	14	14	16	18	10	14	12	12	14	16	8	12	2 x2 x¼	
4½	14	14	16	18	10	14	12	12	14	16	8	12	2 x2 x¼	
5	14	14	16	18	10	14	12	12	14	16	8	12	2 x2 x¼	2 x2 x¼
5½	12	12	16	16	10	14	10	10	14	14	8	12	2 x2½x¼	2 x2 x¼
6	12	12	16	16	10	14	10	10	14	14	8	12	2 x2½x¼	2 x2 x¼
7	12	12	14	16	10	14	10	10	12	14	8	12	2 x2½x¼	2¼x2¼x¼
8	12	12	14	14	10	12	10	10	12	12	8	10	2 x3 x¼	2¼x2¼x¼
9	12	12	14	14	10	12	10	10	12	12	8	10	2 x3 x¼	2½x2½x¼
10	12	12	14	14	10	12	10	10	12	12	8	10	2 x3 x¼	2½x2½x¼
11	12	12	14	12	8	10	10	10	12	10	3	8	2½x3½x¼	2½x2½x⅜
12	12	12	14	12	8	10	10	10	12	10	3	8	2½x3½x¼	3 x3 x⅜
13	12	12	14	12	8	10	10	10	12	10	3	8	3 x4 x⅜	3 x3 x⅜
14	12	12	12	12	8	10	10	10	12	10	3	8	3 x4 x⅜	3½x3 x⅜
15	10	12	12	10	3	8	10	10	10	8	3	8	3 x4 x⅜	4 x4 x⅜
16	10	12	12	10	3	8	8	10	10	8	3	8	3½x5 x⅜	4 x4 x⅜
17	10	12	12	10	3	8	8	10	10	8	3	8	4 x5 x⅜	4 x4 x⅜
18	10	12	12	10	0	8	8	10	10	8	0	8	4 x5 x⅜	4 x4 x⅜
19	10	12	12	8	0	8	8	10	10	8	0	8	4 x5 x⅜	4 x5 x⅜
20	10	10	12	8	0	8	8	8	10	8	0	8	4 x5 x⅜	4 x5 x⅜

All Niagara and Turbo-Conoidal Fans have 32 Blades. Turbo-Conoidal (Type T) Fans have same dimensions as in table above, except blast-wheel and shaft, which may vary, depending on operating conditions.

CHIMNEYS

The following rules for the design of chimneys are given in "Steam," published by the Babcock & Wilcox Company.

(a)—**To find the draft in inches of water produced by a given chimney.** Divide 7.6 by the absolute temperature of the external air ($t_a + 460$); divide 7.9 by the absolute temperature of the gases in the chimney ($t_g + 460$); subtract the latter from the former, and multiply the remainder by the height of the chimney in feet. This may be expressed as

$$d = h\left(\frac{7.6}{t_a + 460} - \frac{7.9}{t_g + 460}\right)$$

(b)—**To find the height of a chimney** to give a specified draft expressed in inches of water: Proceed as above through the first two steps, then divide the required draft by the remainder, and the result will be the height of the chimney in feet. Expressed as a formula,

$$h = \frac{d}{\left(\frac{7.6}{t_a + 460}\right) - \left(\frac{7.9}{t_g + 460}\right)}$$

The draft attainable with any chimney when the temperature of the external air is 70° F, and the temperature of the flue gases 550° F, multiply the height above the grate in feet by 0.0065 and the product is the draft pressure in inches of water.

SIZES OF CHIMNEYS WITH APPROPRIATE HORSEPOWER OF BOILERS

Diam. in Inches	Height of Chimneys and Commercial Horsepower											Side of Square Inches	Effective Area Square Feet	Actual Area Square Feet
	50 Ft.	60 Ft.	70 Ft.	80 Ft.	90 Ft.	100 Ft.	110 Ft.	125 Ft.	150 Ft.	175 Ft.	200 Ft.			
18	23	25	27									16	0.97	1.77
21	35	38	41									19	1.47	2.41
24	49	54	58	62								22	2.08	3.14
27	65	72	78	83								24	2.78	3.98
30	84	92	100	107	113							27	3.58	4.91
33		115	125	133	141							30	4.48	5.94
36		141	152	163	173	182						32	5.47	7.07
39			183	196	208	219						35	6.57	8.30
42			216	231	245	258	271					38	7.76	9.62
48				311	330	348	365	389				43	10.44	12.57
54				363	427	449	472	503	551			48	13.51	15.90
60				505	536	565	593	632	692	748		54	16.98	19.64
66					658	694	728	776	849	918	981	59	20.83	23.76
72					792	835	876	934	1023	1105	1181	64	25.08	28.27
78						995	1038	1107	1212	1310	1400	70	29.73	33.18
84						1163	1214	1294	1418	1531	1637	75	34.76	38.48
90						1344	1415	1496	1639	1770	1893	80	40.19	44.18
96						1537	1616	1720	1876	2027	2167	86	46.01	50.27
102								1946	2133	2303	2462	90	52.23	56.75
108								2192	2402	2594	2773	96	58.83	63.62
114								2459	2687	2903	3003	101	65.83	70.88
120									2990	3230	3452	106	73.22	78.54
126									3308	3573	3820	112	81.00	86.59
132									3642	3935	4205	117	89.19	95.03
138									3991	4311	4608	122	97.75	103.86
144									4357	4707	5031	127	106.72	113.10

TABLE OF AREA AND CIRCUMFERENCE OF CIRCLES

Diameter in Inches	Area		Circumference in Feet	One Side of a Square
	Square Inches	Square Feet		
1	.7854	.0054	.2618	.8862
2	3.140	.0218	.5236	1.7724
3	7.070	.0491	.7854	2.6587
4	12.57	.0873	1.047	3.4549
5	19.63	.1364	1.309	4.4311
6	28.27	.1964	1.571	5.3174
7	38.48	.2673	1.833	6.2036
8	50.27	.3491	2.094	7.0898
9	63.62	.4418	2.356	7.9760
10	78.54	.5454	2.618	8.8623
11	95.03	.6600	2.880	9.7485
12	113.1	.7854	3.142	10.6347
13	132.7	.9218	3.403	11.5209
14	153.9	1.069	3.665	12.4072
15	176.7	1.227	3.927	13.2934
16	201.0	1.396	4.189	14.1796
17	226.9	1.576	4.451	15.0659
18	254.4	1.767	4.712	15.9521
19	283.5	1.969	4.974	16.8383
20	314.1	2.182	5.236	17.7245
21	346.3	2.405	5.498	18.6108
22	380.1	2.640	5.760	19.4910
23	415.4	2.885	6.021	20.3832
24	452.3	3.142	6.283	21.2694
25	.0490.8	3.409	6.545	22.1557
26	530.9	3.687	6.807	23.0419
27	572.5	3.976	7.069	23.9281
28	615.7	4.276	7.330	24.8144
29	660.5	4.587	7.592	25.7006
30	706.8	4.909	7.854	26.5868
31	754.7	5.241	8.116	27.4730
32	804.2	5.585	8.378	28.3594
33	855.3	5.940	8.639	29.2455
34	907.9	6.305	8.901	30.1317
35	962.1	6.681	9.163	31.0179
36	1017.8	7.069	9.425	31.9042
37	1075.2	7.467	9.686	32.7904
38	1134.1	7.876	9.948	33.6766
39	1194.5	8.296	10.21	34.5628
40	1256.6	8.727	10.47	35.4491
41	1320.2	9.168	10.73	36.3353
42	1385.4	9.621	10.99	37.2215
43	1452.2	10.08	11.26	38.1078
44	1520.5	10.56	11.52	38.9444
45	1590.4	11.04	11.78	39.8802
46	1661.9	11.54	12.04	40.7664
47	1734.9	12.05	12.30	41.6527
48	1809.5	12.51	12.57	42.5839
49	1885.7	13.09	12.83	43.4251
50	1963.5	13.64	13.09	44.3113

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TABLE OF AREA AND CIRCUMFERENCE OF CIRCLES

Diameter in Inches	Area		Circumference in Feet	One Side of a Square
	Square Inches	Square Feet		
51	2043	14.19	13.35	45.9760
52	2124	14.75	13.61	46.0838
53	2206	15.32	13.88	46.9700
54	2290	15.90	14.14	47.8562
55	2376	16.50	14.40	48.7425
56	2463	17.10	14.66	49.6287
57	2552	17.72	14.92	50.5149
58	2642	18.35	15.18	51.4012
59	2734	18.99	15.45	52.2874
60	2827	19.63	15.71	53.1736
61	2922	20.29	15.97	54.0598
62	3019	20.97	16.23	54.9061
63	3117	21.65	16.49	55.8323
64	3217	22.34	16.76	56.7185
65	3318	23.04	17.02	57.6047
66	3421	23.76	17.28	58.4910
67	3526	24.48	17.54	59.3772
68	3632	25.22	17.80	60.2634
69	3739	25.97	18.06	61.1497
70	3848	26.73	18.33	62.0359
71	3959	27.49	18.59	62.9221
72	4072	28.27	18.85	63.8083
73	4185	29.07	19.11	64.9946
74	4301	29.87	19.37	65.5808
75	4418	30.68	19.63	66.4670
76	4536	31.50	19.90	67.3500
77	4657	32.34	20.16	68.4800
78	4778	33.18	20.42	69.1500
79	4902	34.04	20.68	70.0290
80	5027	34.91	20.94	70.8950
81	5153	35.78	21.21	71.8000
82	5281	36.67	21.47	73.3500
83	5411	37.57	21.73	73.5540
84	5542	38.48	21.99	74.4460
85	5675	39.41	22.25	75.4785
86	5809	40.34	22.51	76.2170
87	5945	41.28	22.78	77.1038
88	6082	42.24	23.04	77.9871
89	6221	43.20	23.30	78.8733
90	6362	44.18	23.56	79.7621
91	6504	45.17	23.82	80.6473
92	6648	46.16	24.09	81.5389
93	6793	47.17	24.35	82.4196
94	6940	48.19	24.61	83.3060
95	7088	49.22	24.87	84.1902
96	7238	50.27	25.13	85.0760
97	7390	51.32	25.39	85.9650
98	7543	52.38	25.66	86.8500
99	7698	53.46	25.92	87.7380
100	7855	54.54	26.18	88.6280

TEMPERATURE CONVERSION TABLE

Deg. Cent.	Degrees Centigrade= C.									
	0	10	20	30	40	50	60	70	80	90
	Degrees Fahrenheit= F.									
Below 0	+32	+14	−4	−22	−40	−58	−76	−94	—112	−130
Above 0	32	50	68	86	104	122	140	158	176	194
100	212	230	248	266	284	302	320	338	356	374
200	392	410	428	446	464	482	500	518	536	554
300	572	590	608	626	644	662	680	698	716	734
400	752	770	788	806	824	842	860	878	896	914
500	932	950	968	986	1004	1022	1040	1058	1076	1094
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	1274
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	1454
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	1634
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	1814
1000	1832	1850	1868	1886	1904	1922	1940	1958	1976	1994
1100	2012	2030	2048	2066	2084	2102	2120	2138	2156	2174
1200	2192	2210	2228	2246	2264	2282	2300	2318	2336	2354
1300	2372	2390	2408	2426	2444	2462	2480	2498	2516	2534
1400	2552	2570	2588	2606	2624	2642	2660	2678	2696	2714
1500	2732	2750	2768	2786	2804	2822	2840	2858	2876	2894

C.= F.	
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2
10	18.0

F.= C.	
1	0.56
2	1.11
3	1.67
4	2.22
5	2.78
6	3.33
7	3.89
8	4.44
9	5.00
10	5.56
11	6.11
12	6.67
13	7.22
14	7.78
15	8.33
16	8.89
17	9.44
18	10.00

Cent. to Fahr.– $\frac{9C}{5} + 32 = F.$

Fahr. to Cent.– $\frac{5\,(F.-32)}{9} = C.$

PRESSURE IN INCHES OF MERCURY EXPRESSED IN EQUIVALENT POUNDS PER SQUARE INCH

In.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.05	0.10	0.15	0.20	0.25	0.29	0.34	0.39	0.44
1	0.49	0.54	0.59	0.64	0.69	0.74	0.79	0.84	0.88	0.93
2	0.98	1.03	1.08	1.13	1.18	1.23	1.28	1.33	1.38	1.42
3	1.47	1.52	1.57	1.62	1.67	1.72	1.77	1.82	1.87	1.91
4	1.96	2.01	2.06	2.11	2.16	2.21	2.26	2.31	2.36	2.41
5	2.46	2.51	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90
6	2.95	3.00	3.05	3.09	3.14	3.19	3.24	3.29	3.34	3.39
7	3.44	3.49	3.54	3.59	3.63	3.68	3.73	3.78	3.83	3.88
8	3.93	3.98	4.03	4.08	4.13	4.18	4.22	4.27	4.32	4.37
9	4.42	4.47	4.52	4.57	4.62	4.67	4.72	4.76	4.81	4.86
10	4.91	4.96	5.01	5.06	5.11	5.16	5.21	5.26	5.30	5.35
11	5.40	5.45	5.50	5.55	5.60	5.65	5.70	5.75	5.80	5.85
12	5.89	5.94	5.99	6.04	6.09	6.14	6.19	6.24	6.29	6.34
13	6.39	6.43	6.48	6.53	6.58	6.63	6.68	6.73	6.78	6.83
14	6.88	6.93	6.97	7.02	7.07	7.12	7.17	7.22	7.27	7.32
15	7.37	7.42	7.47	7.52	7.56	7.61	7.66	7.71	7.76	7.81
16	7.86	7.91	7.96	8.01	8.06	8.10	8.15	8.20	8.25	8.30
17	8.35	8.40	8.45	8.50	8.55	8.60	8.64	8.69	8.74	8.79
18	8.84	8.89	8.94	8.99	9.04	9.09	9.14	9.19	9.23	9.28
19	9.33	9.38	9.43	9.48	9.53	9.58	9.63	9.68	9.73	9.77
20	9.82	9.87	9.92	9.97	10.02	10.07	10.12	10.17	10.22	10.27
21	10.32	10.37	10.41	10.46	10.51	10.56	10.61	10.66	10.71	10.76
22	10.81	10.86	10.90	10.95	11.00	11.05	11.10	11.15	11.20	11.25
23	11.30	11.35	11.40	11.44	11.49	11.54	11.59	11.64	11.69	11.74
24	11.79	11.84	11.89	11.94	11.99	12.03	12.08	12.13	12.18	12.23
25	12.28	12.33	12.38	12.43	12.48	12.53	12.57	12.62	12.67	12.72
26	12.77	12.82	12.87	12.92	12.97	13.02	13.07	13.11	13.16	13.21
27	13.26	13.31	13.36	13.41	13.46	13.51	13.56	13.61	13.66	13.70
28	13.75	13.80	13.85	13.90	13.95	14.00	14.05	14.10	14.15	14.20
29	14.24	14.29	14.34	14.39	14.44	14.49	14.54	14.59	14.64	14.69
30	14.74	14.78	14.83	14.88	14.93	14.98	15.03	15.08	15.13	15.18

SIZE OF STEAM PIPES

100-Foot Length

Lbs. Steam per Hour	0 Lbs.						5 Lbs.					
	Velocity of Steam in Ft. per Minute											
	6000		9000		12000		6000		9000		12000	
	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.
200	2″	2.1	1½″	1.40	1¼″	1.05	1½″	1.6	1½″	1.07	1″	0.8
400	2½″	4.2	2″	2.81	1½″	2.10	2″	3.2	2″	2.14	1½″	1.6
600	3″	6.3	2½″	4.21	2″	3.16	2½″	4.8	2″	3.20	2″	2.4
800	3½″	8.4	3″	5.61	2½″	4.21	3″	6.4	2½″	4.27	2″	3.2
1000	3½″	10.5	3″	7.03	3″	5.25	3½″	8.0	3″	5.34	2½″	4.0
1200	4″	12.6	3½″	8.40	3″	6.30	3½″	9.6	3″	6.41	2½″	4.8
1400	4½″	14.8	3½″	9.80	3½″	7.40	4″	11.2	3½″	7.48	3″	5.6
1600	5″	16.9	4″	11.22	3½″	8.45	4″	12.8	3½″	8.55	3″	6.4
1800	5″	19.0	4″	12.62	3½″	9.50	4½″	14.4	3½″	9.62	3″	7.2
2000	6″	21.1	4½″	14.0	4″	10.5	4½″	16.0	4″	10.7	3½″	8.0
2200	6″	23.2	4½″	15.4	4″	11.6	5″	17.6	4″	11.7	3½″	8.8
2400	6″	25.3	5″	16.8	4″	12.6	5″	18.2	4″	12.8	3½″	9.1
2600	6″	27.4	5″	18.2	4½″	13.7	5″	20.8	4½″	13.9	4″	10.4
2800	7″	29.5	5″	19.6	4½″	14.7	6″	22.4	4½	14.9	4″	11.2
3000	7″	31.6	6″	21.1	4½″	15.8	6″	24.0	4½″	16.0	4″	12.0
3200	7″	33.7	6″	22.4	5″	16.8	6″	25.6	5″	17.1	4″	12.8
3400	7″	35.8	6″	23.9	5″	17.9	6″	27.2	5″	18.2	4½″	13.6
3600	7″	37.9	6″	25.3	5″	18.9	6″	28.8	5″	19.3	4½″	14.4
3800	8″	40.1	6″	26.7	5″	20.0	7″	30.4	6″	20.3	4½″	15.2
4000	8″	42.2	6″	28.1	6″	21.1	7″	32.0	6″	21.4	4½″	16.0
4200	8″	44.3	7″	29.5	6″	22.1	7″	33.6	6″	22.5	5″	16.8
4400	8″	46.4	7″	30.9	6″	23.2	7″	35.2	6″	23.5	5″	17.6
4600	8″	48.5	7″	32.3	6″	24.2	7″	36.8	6″	24.6	5″	18.4
4800	8″	50.6	7″	33.7	6″	25.3	7″	38.4	6″	25.7	5″	19.2
5000	9″	52.7	7″	35.1	6″	26.3	8″	40.0	6″	26.7	5″	20.0
5500	9″	58.0	7″	38.6	7″	29.0	8″	44.0	6″	29.4	6″	22.0
6000	9″	63.2	8″	42.1	7″	31.6	8″	48.0	7″	32.0	6″	24.0
6500	10″	68.5	8″	45.6	7″	34.2	8″	52.0	7″	34.7	6″	26.0
7000	10″	73.6	8″	49.1	7″	36.8	9″	56.0	7″	37.4	6″	28.0
7500	10″	79.0	9″	52.6	7″	38.5	9″	60.0	8″	40.0	7″	30.0
8000	12″	84.2	9″	56.1	8″	42.1	9″	64.0	8″	42.7	7″	32.0
8500	12″	89.5	9″	59.6	8″	44.7	10″	68.0	8″	45.4	7″	34.0
9000	12″	94.7	9″	63.2	8″	47.3	10″	72.0	8″	48.0	7″	36.0
9500	12″	100.0	10″	66.7	8″	50.0	10″	76.0	8″	50.7	7″	38.0
10000	12″	105.3	10″	70.2	9″	52.6	10″	80.0	9″	53.4	8″	40.0

SIZE OF STEAM PIPES

100-Foot Length

Lbs. Steam per Hour	20 Lbs.						40 Lbs.					
	Velocity of Steam in Ft. per Minute											
	6000		9000		12000		6000		9000		12000	
	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.
200	1¼″	0.94	1″	0.62	1″	0.47	1″	0.61	1″	0.41	1″	0.30
400	1½″	1.87	1¼″	1.25	1¼″	0.93	1¼″	1.22	1¼″	0.82	1″	0.61
600	2″	2.81	1½″	1.87	1½″	1.41	1½″	1.84	1½″	1.23	1¼″	0.92
800	2½″	3.75	2″	2.50	1½″	1.87	2″	2.45	1½″	1.64	1¼″	1.22
1000	2½″	4.68	2″	3.12	2″	2.34	2″	3.07	2″	2.04	1½″	1.53
1200	3″	5.61	2½″	3.76	2″	2.80	2½″	3.68	2″	2.45	1½″	1.84
1400	3″	6.57	2½″	4.37	2″	3.28	2½″	4.28	2″	2.86	2″	2.14
1600	3½″	7.49	2½″	5.00	2½″	3.74	2½″	4.89	2″	3.27	2″	2.44
1800	3½″	8.42	3″	5.63	2½″	4.21	3″	5.50	2½″	3.68	2″	2.75
2000	3½″	9.36	3″	6.25	2½″	4.68	3″	6.12	2½″	4.09	2″	3.06
2200	4″	10.30	3″	6.88	3″	5.15	3″	6.74	2½″	4.50	2½″	3.38
2400	4″	11.22	3½″	7.50	3″	5.61	3½″	7.35	2½″	4.90	2½″	3.67
2600	4″	12.18	3½″	8.13	3″	6.09	3½″	7.96	3″	5.32	2½″	3.98
2800	4½″	13.10	3½″	8.75	3″	6.55	3½″	8.58	3″	5.73	2½″	4.29
3000	4½″	14.05	3½″	9.38	3″	7.02	3½″	9.18	3″	6.14	2½″	4.59
3200	4½″	15.00	3½″	10.00	3½″	7.50	3½″	9.80	3″	6.54	2½″	4.90
3400	4½″	15.95	4″	10.62	3½″	7.98	4″	10.41	3″	6.95	3″	5.20
3600	5″	16.82	4″	11.25	3½″	8.41	4″	11.04	3½″	7.35	3″	5.52
3800	5″	17.78	4″	11.85	3½″	8.89	4″	11.64	3½″	7.77	3″	5.82
4000	5″	18.75	4″	12.50	3½″	9.37	4″	12.25	3½″	8.18	3″	6.12
4200	5″	19.70	4½″	13.20	3½″	9.85	4″	12.87	3½″	8.60	3″	6.43
4400	6″	20.60	4½″	13.75	4″	10.30	4½″	13.48	3½″	9.00	3″	6.74
4600	6″	21.60	4½″	14.35	4″	10.80	4½″	14.10	3½″	9.40	3″	7.05
4800	6″	22.50	4½″	15.00	4″	11.25	4½″	14.70	3½″	9.80	3½″	7.35
5000	6″	23.40	4½″	15.60	4″	11.70	4½″	15.31	4″	10.20	3½″	7.66
5500	6″	26.80	5″	17.15	5″	13.40	5″	16.80	4″	11.20	3½″	8.40
6000	6″	28.10	5″	18.70	5″	14.10	5″	18.40	4″	12.30	3½″	9.20
6500	7″	30.50	5″	20.30	5″	15.20	5″	19.80	4½″	13.30	3½″	9.90
7000	7″	32.80	6″	21.80	5″	16.40	6″	21.40	4½″	14.30	4″	10.70
7500	7″	35.20	6″	23.40	5″	17.60	6″	23.00	4½″	15.30	4″	11.50
8000	7″	37.50	6″	24.90	5″	18.80	6″	24.50	5″	16.30	4″	12.20
8500	8″	39.80	6″	26.50	5″	19.90	6″	26.00	5″	17.30	4½″	13.00
9000	8″	42.20	6″	28.00	6″	21.10	6″	27.60	5″	18.30	4½″	13.80
9500	8″	44.50	7″	29.60	6″	22.20	7″	29.10	5″	19.40	4½″	14.60
10000	8″	46.80	7″	31.20	6″	23.40	7″	30.70	6″	20.40	4½″	15.30

SIZE OF STEAM PIPES

100-Foot Length

Lbs. Steam per Hour	60 Lbs.						80 Lbs.					
	Velocity of Steam in Ft. per Minute											
	6000		9000		12000		6000		9000		12000	
	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.
200	1"	0.46	1"	0.31	1"	0.23	1"	0.37	1"	0.24	1"	0.18
400	1¼"	0.92	1"	0.61	1"	0.46	1"	0.73	1"	0.49	1"	0.36
600	1½"	1.37	1¼"	0.92	1"	0.68	1¼"	1.10	1"	0.73	1"	0.55
800	1½"	1.83	1¼"	1.22	1¼"	0.91	1½"	1.47	1¼"	0.98	1"	0.73
1000	2"	2.29	1½"	1.53	1¼"	1.14	1½"	1.82	1¼"	1.23	1¼"	0.91
1200	2"	2.75	1½"	1.83	1½"	1.37	2"	2.20	1½"	1.47	1¼"	1.10
1400	2"	3.21	2"	2.14	1½"	1.60	2"	2.57	1½"	1.71	1¼"	1.28
1600	2½"	3.67	2"	2.44	1½"	1.83	2"	2.93	2"	1.96	1½"	1.46
1800	2½"	4.13	2"	2.75	2"	2.06	2"	3.30	2"	2.21	1½"	1.65
2000	2½"	4.59	2"	3.15	2"	2.29	2½"	3.67	2"	2.46	1½"	1.83
2200	2½"	5.05	2½"	3.36	2"	2.52	2½"	4.04	2"	2.70	2"	2.02
2400	3"	5.50	2½"	3.67	2"	2.75	2½"	4.40	2"	2.94	2"	2.20
2600	3"	5.96	2½"	3.97	2"	2.98	2½"	4.77	2"	3.19	2"	2.38
2800	3"	6.43	2½"	4.28	2"	3.21	2½"	5.12	2½"	3.43	2"	2.56
3000	3"	6.88	2½"	4.58	2½"	3.44	3"	5.50	2½"	3.68	2"	2.75
3200	3½"	7.35	2½"	4.89	2½"	3.67	3"	5.88	2½"	3.92	2"	2.94
3400	3½"	7.80	2½"	5.19	2½"	3.90	3"	6.22	2½"	4.17	2"	3.11
3600	3½"	8.26	3"	5.50	2½"	4.13	3"	6.60	2½"	4.42	2½"	3.30
3800	3½"	8.71	3"	5.80	2½"	4.35	3"	6.98	2½"	4.67	2½"	3.46
4000	3½"	9.18	3"	6.11	2½"	4.59	3½"	7.33	2½"	4.92	2½"	3.66
4200	3½"	9.63	3"	6.42	2½"	4.81	3½"	7.70	2½"	5.16	2½"	3.85
4400	4"	10.10	3"	6.73	2½"	5.05	3½"	8.08	3"	5.40	2½"	4.04
4600	4"	10.55	3"	7.02	3"	5.27	3½"	8.45	3"	5.65	2½"	4.22
4800	4"	11.00	3½"	7.34	3"	5.50	3½"	8.80	3"	5.90	2½"	4.40
5000	4"	11.48	3½"	7.64	3"	5.74	3½"	9.18	3"	6.15	2½"	4.59
5500	4"	12.60	3½"	8.42	3"	6.30	4"	10.10	3"	6.76	2½"	5.05
6000	4½"	13.80	3½"	9.18	3"	6.90	4"	11.00	3½"	7.39	3"	5.50
6500	4½"	14.90	4"	9.95	3½"	7.45	4"	11.90	3½"	8.00	3"	5.95
7000	4½"	16.10	4"	10.70	3½"	8.10	4"	12.80	3½"	8.60	3"	6.40
7500	5"	17.20	4"	11.50	3½"	8.60	4½"	13.70	3½"	9.23	3"	6.85
8000	5"	18.30	4"	12.30	3½"	9.15	4½"	14.70	3½"	9.84	3½"	7.35
8500	5"	19.50	4½"	13.00	3½"	9.75	4½"	15.60	4"	10.40	3½"	7.80
9000	6"	20.60	4½"	13.80	4"	10.30	5"	16.50	4"	11.10	3½"	8.25
9500	6"	21.80	4½"	14.50	4"	10.90	5"	17.40	4"	11.70	3½"	8.70
10000	6"	23.00	4½"	15.30	4"	11.50	5"	18.30	4"	12.30	3½"	9.15

SIZE OF STEAM PIPES

100-Foot Length

Lbs. Steam per Hour	100 Lbs.						200 Lbs.					
	Velocity of Steam in Ft. per Minute											
	6000		9000		12000		6000		9000		12000	
	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.	D.	Sq. In.
200	1″	0.31	1″	0.20	1″	0.15	1″	0.17	1″	0.11	1″	0.08
400	1″	0.61	1″	0.41	1″	0.31	1″	0.34	1″	0.23	1″	0.17
600	1¼″	0.92	1″	0.61	1″	0.46	1″	0.51	1″	0.34	1″	0.25
800	1¼″	1.22	1″	0.82	1″	0.61	1″	0.68	1″	0.45	1″	0.34
1000	1½″	1.63	1¼″	1.02	1″	0.76	1¼″	0.85	1″	0.57	1″	0.42
1200	1½″	1.83	1¼″	1.22	1¼″	0.92	1¼″	1.02	1″	0.68	1″	0.51
1400	2″	2.14	1½″	1.43	1¼″	1.07	1¼″	1.19	1″	0.79	1″	0.59
1600	2″	2.45	1½″	1.63	1¼″	1.22	1½″	1.36	1¼″	0.91	1″	0.68
1800	2″	2.76	1½″	1.83	1½″	1.38	1½″	1.53	1¼″	1.02	1″	0.76
2000	2″	3.06	2″	2.04	1½″	1.53	1½″	1.70	1¼″	1.13	1¼″	0.85
2200	2½″	3.37	2″	2.24	1½″	1.68	1½″	1.87	1¼″	1.25	1¼″	0.93
2400	2½″	3.67	2″	2.45	1½″	1.84	2″	2.04	1½″	1.36	1¼″	1.02
2600	2½″	3.98	2″	2.65	2″	1.99	2″	2.21	1½″	1.47	1¼″	1.10
2800	2½″	4.28	2″	2.85	2″	2.14	2″	2.38	1½″	1.59	1¼″	1.19
3000	2½″	4.59	2″	3.06	2″	2.29	2″	2.55	1½″	1.70	1¼″	1.27
3200	2½″	4.90	2″	3.26	2″	2.45	2″	2.72	1½″	1.81	1½″	1.36
3400	3″	5.20	2½″	3.47	2″	2.60	2″	2.89	2″	1.93	1½″	1.44
3600	3″	5.52	2½″	3.67	2″	2.76	2″	3.06	2″	2.04	1½″	1.53
3800	3″	5.82	2½″	3.88	2″	2.91	2″	3.23	2″	2.15	1½″	1.61
4000	3″	6.13	2½″	4.08	2″	3.06	2½″	3.40	2″	2.26	1½″	1.70
4200	3″	6.44	2½″	4.29	2″	3.22	2½″	3.57	2″	2.38	1½″	1.78
4400	3″	6.75	2½″	4.49	2½″	3.37	2½″	3.74	2″	2.49	1½″	1.87
4600	3″	7.05	2½″	4.69	2½″	3.52	2½″	3.91	2″	2.61	2″	1.96
4800	3½″	7.35	2½″	4.90	2½″	3.67	2½″	4.08	2″	2.72	2″	2.04
5000	3½″	7.65	2½″	5.10	2½″	3.82	2½″	4.25	2″	2.83	2″	2.12
5500	3½″	8.42	3″	5.62	2½″	4.21	2½″	4.68	2″	3.12	2″	2.34
6000	3½″	9.18	3″	6.13	2½″	4.59	2½″	5.10	2½″	3.40	2″	2.55
6500	4″	9.95	3″	6.64	2½″	4.97	3″	5.53	2½″	3.68	2″	2.76
7000	4″	10.70	3″	7.15	3″	5.35	3″	5.95	2½″	3.97	2″	2.97
7500	4″	11.46	3½″	7.66	3″	5.73	3″	6.48	2½″	4.25	2″	3.24
8000	4″	12.22	3½″	8.17	3″	6.11	3″	6.80	2½″	4.53	2½″	3.40
8500	4½″	13.00	3½″	8.68	3″	6.50	3″	7.22	2½″	4.82	2½″	3.61
9000	4½″	13.75	3½″	9.19	3″	6.87	3½″	7.65	2½″	5.10	2½″	3.82
9500	4½″	14.50	3½″	9.70	3½″	7.25	3½″	8.08	3″	5.38	2½″	4.04
10000	4½″	15.26	4″	10.20	3½″	7.63	3½″	8.50	3″	5.66	2½″	4.25

PROPERTIES OF SATURATED STEAM

Temp.	Approx. Gauge Press.	Density	Spec. Vol. Cu. Ft. per Lb.	Heat of Liquid	Latent Heat	Total Heat
212	0	.03732	26.79	180.00	970.4	1150.4
215	1	.03945	25.35	183.00	968.4	1151.5
219	2	.04243	23.57	187.10	965.9	1152.9
222	3	.04477	22.34	190.10	963.9	1154.0
224	4	.04640	21.55	192.10	962.6	1154.8
227	5	.04892	20.44	195.20	960.7	1155.8
230	6	.05160	19.39	198.20	958.7	1156.9
232	7	.05340	18.72	200.20	957.4	1157.6
235	8	.05620	17.78	203.20	955.4	1158.7
237	9	.05820	17.17	205.30	954.1	1159.4
239	10	.06020	16.60	207.30	952.8	1160.0
250	15	.07240	13.82	218.50	945.3	1163.8
259	20	.08370	11.95	227.60	939.1	1166.7
267	25	.09490	10.54	235.80	933.5	1169.3
274	30	.10570	9.46	242.90	928.6	1171.5
281	35	.11740	8.51	250.10	923.5	1173.6
287	40	.12830	7.79	256.20	919.1	1175.3
292	45	.13800	7.24	261.30	915.4	1176.8
298	50	.15040	6.65	267.50	911.0	1178.5
307	60	.17070	5.86	276.80	904.2	1181.0
316	70	.19300	5.19	286.10	897.3	1183.3
324	80	.21480	4.66	294.30	891.0	1185.4
331	90	.23530	4.25	301.60	885.5	1187.1
338	100	.25750	3.88	308.90	879.9	1188.8
344	110	.27780	3.60	315.10	875.1	1190.2
350	120	.29920	3.34	321.40	870.1	1191.5
356	130	.32210	3.10	327.70	865.2	1192.9
361	140	.34230	2.92	332.90	861.0	1193.9
366	150	.36310	2.75	338.20	856.8	1195.0

From the steam tables of Marks & Davis

BUFFALO PROGRESSIVE LUMBER DRY KILN
STANDARD SIZES

	Size of Dry Kiln		Size of Apparatus House in Feet	Holding Capacity of Kiln	For Two Tracks in Kiln				For Three Tracks in Kiln				No. of Sheave Pulleys	Wire Rope in Feet	Size of Fan in Inches	Feet Fan System Heater
					Number of				Number of							
	No. of Drying Rooms	Size of Each Room in Feet			Lumber Trucks	Truck Wheels and Spindles	Bolts and Nuts with Washers	12-lb. T-Rails in Feet	Lumber Trucks	Truck Wheels and Spindles	Bolts and Nuts with Washers	12-lb. T-Rails in Feet				
Single Kiln	One	15 x 17 x 9	12 x 8	8000	8	16	32	84	12	24	48	96	8	85	40	553
	One	22 x 17 x 9	12 x 8	12000	10	20	40	84	15	30	60	126	8	85	50	1108
	One	27 x 17 x 9	13 x 8	16000	12	24	48	126	18	36	72	140	8	85	60	1385
	One	33 x 17 x 9	13 x 8	20000	14	28	56	138	21	42	84	169	8	85	60	1585
	One	43 x 17 x 9	13 x 8	24000	16	32	64	150	24	48	96	189	8	85	70	1980
	One	64 x 17 x 9	14 x 10	36000	22	44	96	166	33	66	132	252	8	85	80	2730
	One	85 x 17 x 9	15 x 10	50000	28	56	128	210	42	84	168	315	8	85	90	2990
Double Kiln	Two	22 x 17 x 9	13 x 8	24000	20	40	80	164	30	60	120	252	16	170	70	1980
	Two	43 x 17 x 9	14 x 9	50000	32	64	128	252	48	96	192	378	16	170	80	2730
	Two	64 x 17 x 9	15 x 10	75000	44	88	176	336	66	132	264	504	16	170	90	3270
	Two	85 x 17 x 9	17 x 12	100000	56	112	224	420	84	168	336	630	16	170	110	4860
Triple Kiln	Three	22 x 17 x 9	14 x 9	36000	30	60	120	252	45	90	180	378	24	255	80	2730
	Three	43 x 17 x 9	15 x 10	75000	48	96	192	373	72	144	288	576	24	255	90	3270
	Three	64 x 17 x 9	17 x 12	110000	66	132	264	500	99	198	396	756	24	255	110	4860
	Three	85 x 17 x 9	20 x 14	150000	84	168	336	625	126	252	504	940	24	255	120	6350
Quadruple Kiln	Four	22 x 17 x 9	14 x 9	48000	40	80	160	336	60	120	240	504	32	340	90	3270
	Four	43 x 17 x 9	17 x 12	96000	64	128	256	504	96	192	384	672	32	340	110	4860
	Four	64 x 17 x 9	20 x 14	144000	88	176	352	672	132	264	528	1008	32	340	120	5960
	Four	85 x 17 x 9	22 x 26	192000	112	224	448	840	168	336	672	1260	32	340	140	8030
	Five	85 x 17 x 9	24 x 20	240000	140	280	560	1050	210	420	804	1575	40	425	2—120	9020
	Six	85 x 17 x 9	26 x 22	300000	168	336	672	1260	252	504	1008	1890	48	510	2—130	10340
	Eight	85 x 17 x 9	32 x 26	400000	224	448	896	1680	336	672	1344	2520	64	680	2—140	12700
	Ten	85 x 17 x 9	36 x 28	500000	280	560	1120	2100	420	840	1680	3150	80	850	3—150	16640

LOGARITHMS

Nat. Nos.	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7

LOGARITHMS

Nat. Nos.	0	1	2	3	4	5	6	7	8	9	Proportional Parts								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

USEFUL FACTORS

1 gal. (U. S.) =231 cu. in.
=0.13368 cu. ft.
1 gal. (British) =277.274 cu. in.
1 cu. ft. =7.4805 gals.
1 cu. ft. water at 60° F. =62.37 lbs.
1 gal. water at 60° F. =8.34 lbs.
1 cu. ft. water at 212° F. =59.76 lbs.
1 gal. water at 212° F. =7.99 lbs.
1 barrel water at 60° F. =31½ gals. =262.7 lbs.
1 in. mercury =1⅛ ft. or 13.6 in. water
=0.491 lb. per sq. in.
1 lb. per sq. in. press. =2.304 ft. water at 60°
Height of a column of water in feet × 0.434 =lb. press. per sq. in.
A column of water 1 sq. in. and 2⅓ ft. high =approximately 1 lb.
1 calorie =3.97 B. t. u.
1 kilogram =2.2046 lbs.
Calories per kilo × 1.8 =B. t. u. per lb.
1 kilowatt (1000 watts) =1.3405 H. P.
1 horsepower =0.746 K. W.
1 kilowatt =56.9 B. t. u. per min.
1 mech. horsepower =42.4 B. t. u. per min.
=2545 B. t. u. per hour
=33000 ft. lbs. per min.
1 boiler horsepower =33479 B. t. u. per hour
1 B. t. u. =778 ft. lbs.
1 ft. lb. per sec. =1.356 watts

WATER CONVERSION FACTORS*

U. S. gallons ×8.33 = pounds
U. S. gallons ×0.13368 = cu. ft.
U. S. gallons ×231. = cu. in.
U. S. gallons ×3.78 = liters
Cu. in. water at 39.1° ×0.036024 = pounds
Cu. in. water at 39.1° ×0.004329 = U. S. gal.
Cu. in. water at 39.1° ×0.576384 = ounces
Cu. ft. water at 39.1° ×62.425 = pounds
Cu. ft. water at 39.1° ×7.48 = U. S. gal.
Cu. ft. water at 39.1° ×0.028 = tons
Pounds of water ×27.72 = cu. in.
Pounds of water ×0.01602 = cu. ft.
Pounds of water ×0.12 = U. S. gal.

MEASURES OF PRESSURE AND WEIGHT†

1 lb. per sq. in. =	144 lbs. per sq. ft. 2.0416 in. mercury at 62° F. 2.309 ft. water at 62° 27.71 in. water at 62°
1 oz. per sq. in. =	0.1276 in. mercury at 62° 1.732 in. water at 62°
1 atmosphere (14.7 lbs. per sq. in.) =	2116.3 lbs. per sq. ft. 33.947 ft. water at 62° 30 in. mercury at 62° 29.922 in. mercury at 32°
1 in. water at 62° F. =	0.03609 lb. or .5774 oz. per sq. in. 5.196 lbs. per sq. ft.
1 ft. water at 62° F. =	0.433 lb. per sq. in. 62.355 lbs. per sq. ft.
1 in. mercury at 62° F. =	0.491 lb. or 7.86 oz. per sq. in. 1.132 ft. water at 62° 13.58 in. water at 62°

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*American Machinist Hand Book.

†Kent's Mechanical Engineers' Pocket Book.

REPORT OF COMMITTEE OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS ON STANDARDS FOR VENTILATION LEGISLATION FOR MOTION PICTURE SHOW PLACES

January, 1913

Ventilation and sanitation requirements cannot be too strongly emphasized when dealing with the question of legislation relating to motion picture show places. The widespread neglect, in a very large number of communities throughout the country, of proper ventilation and sanitation in such motion picture show places, has many times been correctly characterized as a "menace to public health"—materially affecting the moral tone as well.

Allowing the great importance of fire protection and structural requirements for the protection of **life**; elimination of low-class vaudeville, enforced lighting during performances, supervision of pictures exhibited, and other essential matters for the protection of **morals**; ventilation and sanitation requirements loom up large for the protection of **health.**

The Committee has been appointed to deal with the subject of ventilation and this question is, of course, vitally concerned with all the conditions of the air breathed, particularly **temperature, air purity, air motion, humidity,** and **freedom from dust** (impurities from breathing, skin exhalations, dust, etc., being constantly released in large quantities in every audience hall).

With a view of suggesting minimum requirements that are practical to secure, the following recommendations are made as standards for legislation to cover this important phase of the needed general regulations for motion picture show places.

MINIMUM VENTILATION STANDARDS

1. Floor Area per Occupant.

A **minimum** of 4⅓ sq. ft. of floor area, as a seating space, per occupant, exclusive of aisles and public passageways, shall be provided in the audience hall.

2. Cubic Space per Occupant.

A **minimum** of 80 cu. ft. of air space, per occupant, shall be provided in the audience hall.

3. Quantity of Outdoor Air.

A positive supply of outdoor air from an uncontaminated source shall be provided the audience hall at all times while the show place is open to the public, and the quantity of this positive supply of outdoor air shall be based on a **minimum** requirement of 15 cu. ft. per minute, per occupant.*

4. Temperature.

The temperature of the air in the audience hall shall at all times, while the show place is open to the public, be maintained throughout at the breathing line (persons being seated) within the range of 62° F. to 70° F. (except when the outside temperature is sufficiently high not to require the air supply for ventilation to be heated). **The temperature, distribution and diffusion of the supplied outdoor air shall be such as to maintain the temperature requirement without uncomfortable drafts.**

5. Direct Heat Sources.

Any good heat source which does not contaminate the air will be accepted to supplement the warmed outdoor air supply. Gas radiators are prohibited.

6. Machine Booth Ventilation.

Enclosures or booths for the motion picture machines shall be provided with special exhaust ventilation with a capacity to exhaust at all times not less than 60 cu. ft. of air per minute through a one-machine booth, not less than 90 cu. ft. of air per minute through a two-machine booth, and not less than 120 cu. ft. of air per minute through a three-machine booth.

This requirement shall include a number of small metal screened openings (equipped with special dampers and automatic appliance with fusible link to automatically close tight in case

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*The ordinance in force in the City of Chicago at the present time requires that the air in the auditorium in the class of buildings in which motion picture show places are included, shall be changed so as to supply for each person for whom seating accommodation is provided, at least 1500 cu. ft. of air per hour for new buildings, and at least 1200 cu. ft. of air per hour for buildings constructed prior to the passage of the ordinance, which requirements the Illinois Chapter of the Society considers practical to obtain and desirable to require by legislation for motion picture show places.

Higher standards of ventilation than set forth as minimum in the committee's report are urged wherever possible to obtain.

of fire in the booth) on the sides of the booth near the bottom, aggregating 180 sq. in. for a one-machine booth, 210 sq. in. for a two-machine booth, and 240 sq. in. for a three-machine booth; and this requirement shall also include a metal or other fireproof flue, extending from the top or side at the top of the booth, and carried to a proper place of discharge outdoors. The ventilation should be augmented by mechanical or other means, so as to exhaust at least the quantity of air as herein stated.

The size of this special fireproof vent flue shall be not less than 96 sq. in. clear area for a one-machine booth, not less than 120 sq. in. clear area for a two-machine booth, and not less than 144 sq. in. clear area for a three-machine booth, and this special vent flue shall be provided with an adjustable damper, operated from the booth, and equipped with an automatic appliance and a fusible link to operate so as to open the damper wide automatically in case of fire in the booth. The machine booth ventilation shall be kept in operation at all times when the booth is in use.

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It will be noted that the foregoing regulations are simple, and that violations may be readily detected, also that care has been exercised to leave large latitude for design of the ventilating apparatus.

It should be especially noted that the foregoing regulations call for a **minimum** of all requirements as compulsory, and that **it should be the aim of the administrative department having enforcement of the regulations in charge to encourage motion picture show owners and managers to provide as comprehensive, liberal, and high-class equipment as possible,** with a view to catering to the comfort and health of the patrons and thus add to the popularity of the show place as compared with others which may have barely come within the legal requirements.

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Elimination of dust from the air supply by means of air filters or air washers is desirable under the best conditions and is imperative under some conditions of especially dusty air supply. This question is dealt with by suggestion in the following general clauses.

The controlling of relative humidity is desirable, whenever possible, but the Committee decided to omit from the regulations any humidity requirement.

The machine booth ventilation, as per recommended regulations, would be greatly improved, especially for summer conditions, by providing a duct connection from out of doors to the bottom of the booth, for the introduction of outdoor air directly to the booth. * * * * *

Strong emphasis is placed on the need of having the administrative feature of legislation of the kind here advocated, placed in the control of a responsible department, * * * * * * * and that such department be supplied with a special inspector or inspectors, experienced in heating, ventilation, and sanitation, and that such department be given reasonable latitude by legislation, such as to require approval of plans preceding installation or to require special extra equipment for special cases, such as dust filters for air supply where the air supply is especially dust laden; exhaust ventilation of toilets where building laws do not properly cover this matter; fans in the auditorium, to keep the air in motion where diffusion is insufficient, etc., it being made clear in the legislation that such latitude should in no case include the right to reduce the stated minimum requirements. The administrative department should also be given the support of other local or state departments, as the case may be, such as the fire department, police department, health department, etc.

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